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METEOROLOGICAL OBSERVATIONS IN ASSAM 1926.

By

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In describing below the general weather conditions in Assam during 1926 it is realised that the degree of correlation between the weather and its effect on the tea bush is, so far, a very small one. Eventually, as the number of observations increases, the degree of correlation which can be followed will no doubt be much greater, but at present there is little more than the actual yield to consider in relation with the weather. Yield alone is most confusing, for it is the final result of a great number of factors. Yield can only be understood when growth is understood.

In addition to the weather, the method of cultivation and plant treatment has an influence on the crop, which varies with the weather. When it is considered that the incidence of pests and blights is also influenced by the weather, the difficulties of the problem of crop correlation with meteorological observations, in the light of our meagre knowledge, will be understood.

The 1926 Season in Assam.—The first rain at Tocklai fell on January 9th after a drought lasting 61 days.

In March, growing conditions were excellent and the bushes started to flush early. In April however only 2.1 inches of rain was registered, the lowest on record. The May rainfall was about average, but most of it fell in the first fortnight so that during the latter half of the month rainfall was short.

During the first half of June rain was again short and this, combined with the high temperatures and fierce sun, was followed by a severe attack of rim blight. From the table given below it will be seen that growing conditions were much less favourable than during the corresponding period in 1925.

METEOROLOGICAL OBSERVATIONS IN ASSAM 1926.

The Period 14th May to 14th June.

	1925.	1926.
Temperature Maximum	86·0°F	90·9°F
Rainfall	13·31 ins.	6·85 ins.
Degree of wetness	10·7	3·4
Sunshine	4·7 hrs.	6·1 hrs.
Wind	57 miles/day	42 miles/day
Humidity	82	76
Soil Moisture	17·5%	16·4%

The second flush materialised in June, but the bushes afterwards failed to give much leaf till the blight went. The weather in July, August and September was ideal and crops were big during those months.

The first half of October was blazing hot and humid, and everything pointed to a good back-end. From the middle of the month, however, temperature fell off sharply and humidity decreased, with the result that November was normal and December poor.

The following table shows the rapid change to cold weather conditions after the middle of October.

Week ending.	Temperature. Max.	Temperature. Min.	Average Relative Humidity.	Total Rainfall.	Total Sunshine.
30th September ...	90·0°F	73·3°F	93	2·34 ins.	42 hrs.
7th October	90·6°F	73·6°F	90	1·85 ins.	35 hrs.
14th October	85·3°F	69·6°F	89	1·37 ins.	38 hrs.
21st October ..	86·3°F	70·2°F	88	0·52 ins	38 hrs.
28th October ...	82·3°F	65·7°F	91	0·71 in	30 hrs.
4th November ...	82·0°F	61·5°F	95	nil.	44 hrs.
11th November	81·0°F	57·2°F	97	nil.	51 hrs.

The rise in relative humidity at 8 A.M., after the middle of October, indicates the commencement of morning fogs and mists.

The end of the season is governed largely by the temperatures, which are in turn controlled by the movement of the monsoon. The table below shows the average maximum and

minimum temperatures from September to the end of the year for past eight seasons.

Table showing maximum and minimum temperatures at Tocklai.

Season.	September.		October.		November.		December.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	°F	°F	°F	°F	°F	°F	°F	°F
1919	85	75	83	72	78	64	73	54
1920	89	76	85	70	81	59	75	52
1921	88	75	82	71	80	60	72	53
1922	89	76	85	68	80	59	73	50
1923	87	76	84	69	80	60	74	50
1924	88	75	87	73	77	62	73	54
1925	87	72	83	66	79	53	73	43
1926	89	72	86	69	79	55	74	49
Average	88	75	84	70	79	59	73	51

November 1926, it will be observed, is the second coldest on record, nearly approaching last year, when the season's close was very early.

Below is a table showing the rainfall at Tocklai during 1926 together with the average for the past nine years.

Table showing rainfall at Tocklai.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Total.
Average 9 years	0·95	1·35	3·59	7·89	9·66	12·45	17·04	13·04	10·11	4·47	0·92	0·37	81·79
1926	0·81	0·73	6·72	2·10	8·56	9·73	19·43	14·35	6·72	5·54	0·92	0·37	74·67

As the number of years during which our observations have been taken increases, the average becomes of more value, and any departure from such average gains in significance. It is interesting to note that the average rainfall at Jorhat, two miles from Tocklai, taken over a period of 50 years is 81.89 and the monthly average closely agrees with that at Tocklai.

Air Movement.

The total air movement is measured daily at Tocklai. At present only two and a half years' records are available and they are quot-

ed below in full. The figures denote average miles of wind per day.

Table showing wind at Tocklai.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1924 ...	...	...	...	...	...	40	40	37	31	27	24	13
1925 ...	42	37	55	74	39	44	46	45	46	26	16	16
1926 ...	22	43	55	74	55	47	48	40	30	21	20	18

The increase in wind up to April is marked in both years, as is also the decline as the monsoon weakens. Although in 1925 there were windy days, *e.g.*, January 14th, 404 miles, April 28th, 490 miles, no such windy days were registered in 1926, although 135 miles were registered once in April.

The violent wind storms expected early in the year, which usually do serious damage, have been absent for the past three years.

Sunshine.

The table shows the average monthly sunshine in hours, recorded for the past nine years at Tocklai, together with the values for 1926.

Table showing sunshine at Tocklai.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average (9 years)	5·3	5·7	5·7	4·9	4·7	4·2	4·0	4·4	3·9	5·8	5·6	5·2
1926 ...	5·4	5·5	5·2	5·9	5·5	4·4	3·6	4·8	4·1	5·1	6·8	5·9

It is well known that in the entire absence of light plants become yellow, owing to loss of green colouring matter, or chlorophyll. It is this chlorophyll which, in some way not yet understood, brings about the building up of complete plant constituents and tissue under the influence of light. This process is known as photosynthesis. Sunlight is composed of seven

visible light rays—*viz.*, red, orange, yellow, green, blue, indigo and violet known collectively as the "visible spectrum." There are in addition the invisible "infra-red," or heat rays, and the "ultra violet" rays, also invisible, which affect the photographic plate.

Plant growth is stimulated by heat up to about 90° F but much above this temperature, definite harm results. Although the sun temperature during the rains is generally above 130°F, the temperature of leaf itself is much lower, owing to the cooling effect of transpiration of moisture from the leaf cells. However, at times it is obvious from the sun scorching and yellowing that takes place during very dry hot spells, that the temperature of the leaf is too high for normal growth.

During the rains, though the sun temperature is at its maximum, there are less actual hours of sunshine per day, and the air and soil are more humid than during the cold weather. This explains why the foliage of the bush remains green during the rains, but yellows as the cold weather approaches.

Our sunshine recorder does not measure the intensity of the sun, but only the number of hours of bright sunshine. A measure of the intensity of sunshine is obtained by use of the Solar radiation thermometer, described in a previous number of the Journal.

It is the power of these heat rays mainly which the Solar radiation thermometer records. During the cold weather the angle of the sun in the sky is lower than in the rains for a corresponding period of the day. This means that the rays are more concentrated during the rainy season than in the cold weather and, in the former case, are more powerful. The table below shows the effect of the angle of the sun on the solar radiation, or intensity of heat rays.

Average Monthly Solar Radiation.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Solar radiation in °F ...	105	108	121	125	133	136	137	133	135	130	121	114

The values agree fairly well with those of 1925, except that in the latter year the temperatures at the end of the season were lower. Thus October 1925 showed a value of 123° F, November 116° F, and December 105° F.

This value must be taken in connection with the hours of sunshine, for if the sun appears for a short period the same maximum solar radiation may be registered as when it shines for a whole day. Thus on two consecutive days in July the solar radiation was 139°F and 138° F. On the first day the sun shone for 6½ hours and on the second day for 12 minutes.

Regarding light intensity, it has been observed that light favours the formation of small leaves, whilst low light intensity favours the formation of large leaves. The most favourable intensity, however, varies with time of exposure. These observations fit in with our experience in tea, where heavy shade "draws up" the bush and makes coarse leaf.

Again, in connection with light intensity, it has been noticed that light-leaved bushes are in more need of shade than dark-leaved bushes.

The study of sunshine is also important from the point of view of blight attack. It has been noticed that a dull, humid spell makes for the spread of Brown and Grey blights. In this connection the sunshine records at Sylee, in the Dooars, and at Toklai for the past two years are of interest.

The first table shows the hours of sunshine per mensem at Sylee.

Hours of sunshine at Sylee.

	April.	May.	June.	July.	Aug.	Sept.
1925	118	101	124	94	96	86
1926	180	147	91	68	127	170

Hours of sunshine at Tocklai.

	April.	May.	June.	July.	Aug.	Sept.
1925	105	102	156	158	135	117
1926	177	170	131	112	149	124

A sunny season, especially a sunny spring, in the Dooars is associated with light mosquito attack. No sunshine records other than those quoted above are available for the Dooars, but it seems probable that what is regarded as a sunny season in the Dooars may show a record of hours of sunshine no greater than is the general average in Assam. In Sylhet where, from experience only, it is assumed that the hours of sunshine exceed those in Assam, a sunny start means a severe drought usually, and a serious weakening of the bushes.

If, as often happens, May and June are fairly dry, the effect of excessive sunshine will be considerable, since the sun's power is greater during June than at any time of the year, the sun reaching its maximum altitude on the 21st of June.

Soil Temperatures.

In the plains of North-East India the soil temperatures, even at a depth of three feet, never fall below 60° F and remain over 75° F during the plucking season. During the rains the surface temperature is above that at about three feet depth, and the close of the plucking season is marked by a drop in the surface temperature below that at three feet, this state of affairs persisting throughout the cold weather until the rains and the plucking season commence again.

Below are given the average monthly soil temperatures for the past four years, taken at depths of one foot and three feet, at 8 A.M. and 3 P.M.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
8 A.M.												
1 ft.	63·22	65·82	70·65	74·22	80·06	84·96	86·62	86·50	85·08	81·98	73·20	55·48
3 ft.	67·20	68·29	71·60	76·19	79·37	84·41	86·06	86·15	85·60	82·12	76·80	70·52
3 P.M.												
1 ft.	65·61	68·16	73·51	78·51	82·08	87·51	88·20	88·81	86·19	83·05	75·07	60·33
3 ft.	67·40	68·07	71·88	76·26	79·50	84·43	86·10	86·99	85·57	82·91	76·92	71·01

It will be seen from the above table that from about the end of April to the middle of August the soil temperature at 8 A.M. is constant to a depth of three feet but by the afternoon the surface of the soil has warmed up. At the end of

January and November the soil temperature was constant to three feet depth during the afternoon, but during the morning the surface was cooler than the underlying layer.

Soil Moisture.

The question of the amount of water in a soil is of primary importance in agriculture, since plant growth is directly dependent on water, not only as a medium for the transport of plant food, but as a means of bringing the various cell and tissue-building materials into close juxtaposition so that synthesis may take place. There is however an optimum moisture content, which, if exceeded, results in harm to the bush. With too much water in the soil, nitrogen-fixing, and nitrifying bacteria, which require air, are unable to work, and their place is taken by harmful bacteria which do not require air, and undo the work of the bacteria which assist plant growth.

The only source of soil water in practically every tea area is rainfall which is unevenly distributed throughout the year. During the rains, there are nearly always long spells when there is a surfeit of rain, and undrained land becomes waterlogged. During the cold weather, there are periods of drought when the soil dries out unless measures such as mulching and shading are taken to prevent or minimise such drying.

The optimum water content of the Tocklai soil is about 17 or 18 per cent. During the cold weather 1925-1926, with a sixty days' drought from the middle of November to the middle of January, the soil moisture fell as low as 8.5 per cent. and remained at about 10 per cent. until the beginning of March. The highest percentage moisture recorded last year was 21 per cent., while from the beginning of May to the end of November, the soil moisture remained close to the optimum.

Soil Moisture at Tocklai.

	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1926	11%	10%	16%	14%	17%	17 %	19%	19%	18%	17·7%	15%	13·7%
1927	15%	15%										

It will be seen that the cold weather of 1926-27 has witnessed a very different state of affairs from the preceding cold weather. At no time has there been any drying out of the soil, which is in excellent condition, and, unless a very prolonged drought occurs before the rains come, the 1927 season should prove an ideal one from a point of view of the health of the tea bush.

Relative Humidity.

During January the relative humidity was 90-100 per cent. for about 12 hours during each day. From 7-30 P.M., the humidity drops gradually to 60 per cent. or 55 per cent. at 4 P.M., after which it again rises to nearly 100 per cent. at 7-30 P.M. At mid-day the humidity varies considerably—on wet cloudy days remaining at 85 or 90 per cent., and on dry days dropping to 70-75 per cent.

During February the humidity at night is still 100 per cent. but the drop during the day is greater, and the humidity at 4 P.M. is as low as 40-50 per cent.

In March and April, with its cool rainy spells and occasional spells of hot dry weather, the humidity varies considerably from day to day. During dry spells the daily drop in humidity is as much as 60 per cent, while on wet days the drop may be only 35 or 40 per cent.

By the middle of April the humidity seldom drops below 60 per cent. and, by the time the monsoon arrives, in June the humidity remains generally between 100 per cent. and 70 per cent.

The beginning of October is marked by a drop in night and day humidity, the former to a maximum of 90 per cent. or 95 per cent. and the latter back to 60 per cent.

During November, the night air is saturated, causing fogs, this state of affairs persisting usually throughout the cold weather.

ANALYSIS OF PHOSPHATIC MANURES.

By

H. R. Cooper and P. B. Sen Gupta.

In connection with the trials of phosphatic manures reported in the last number of this Journal a number of analyses were performed.

This was done with the primary object of defining the material which was tried. Very different mineral phosphates may be exported, for example, from Belgium or Algeria; basic slags, superphosphates, and bone dusts differ in quality; while mineral phosphates, treated or untreated, which are sold under particular trade names, convey by their names no idea of their nature.

As a secondary object it was desired to discover whether there was a correlation between any of the figures obtained by analysis, and the efficiency of the manure as determined by an actual field test.

Field tests require a long time to carry out; entail relatively high expenditure and use of labour; and the results obtained are subject to a fairly high degree of error, and apply strictly only to the particular soil on which the trial was made.

If it could be shown that analytical figures obtained in the laboratory were related to figures from field trials, it would be possible to reduce greatly the number of field trials required.

The addition of a phosphatic manure produces changes in the soil in two main directions.

First. The amount of phosphoric acid available to plants growing in the soil is increased.

Second. The acidity of the soil may be changed significantly.

Leguminous plants are benefited greatly on our acid soils, both by addition of available phosphoric acid and by decrease in the acidity of the soil. The presence of large quantities of iron-oxide and alumina in the manure added might possibly prove harmful, since, if sufficiently soluble, they might combine with phosphoric acid to form very insoluble compounds.

The determinations shown in Table I therefore, were made.

Table I.

	Per cent.						
	Total phosphoric acid.	Phosphoric acid soluble in 2 % citric acid.	Oxides of iron & alumina.	Total lime.	Lime as carbonate.	Acidity reducing power equivalent to lime.	Total nitrogen.
	1	2	3	4	5	6	7
Basic slag	17·86	14·80	24·8	44·74	1·8	37·7.	trace
Superphosphate	20·85	water soluble	...	...	nil	—10·5	trace
Bone dust	21·19	13·20	...	25·88	nil	12·1	3·25
Algerian phosphate	26·54	9·57	10·6	38·42	6·6	29·29	0·46
Belgian phosphate	23·94	2·04	10·0	42·84	17·4	35·78	trace
Plutophos	35·47	6·51	4·0	46·54	2·2	25·26	trace
Radiophos	23·47	6·89	28·4	29·18	nil	5·26	trace
Singhbhum phosphate	35·21	2·36	15·4	45·30	nil	15·23	trace
Indophos	26·03	1·78	10·4	37·30	nil	15·12	trace

The figure in the sixth column was determined by treating a weighed quantity of the material with decinormal hydrochloric acid, and bringing just to boiling. The amount of hydrochloric acid neutralised was then determined by titration with caustic soda. Superphosphate, of course, has no power of neutralising acid, but, on the contrary, is acid itself, and this particular sample is sufficiently acid to neutralise 10½ per cent. of its own weight of lime. Its "acidity reducing power" is therefore entered as a negative quantity.

Comparison of these figures is best made by calculating from the above figures the quantities per acre actually added to the soil, and comparing these with the relative efficiencies of the manures as determined by field trial.

Table II

	Relative efficiency in field trial.	lbs. applied per acre.			
		Total Phosphoric acid.	Phosphoric acid soluble in 2% citric acid.	Acidity reducing power equiv. to lbs. lime.	Nitrogen.
Basic slag ...	100	80	64·5	169	nil
Superphosphate ...	87	80	(water soluble)	nil, on contrary neutralises 40 lbs. lime.	nil
Bone dust ...	82	80	49·8	46	12·1
Algerian phosphate ...	85	80	28·8	88	1·4
Belgian phosphate ...	60	80	7·4	131	nil
Plutophos... ...	32	80	14·6	57	nil
Radiophos ...	13	80	3·1	18	nil
Singhbhum phosphate	5	80	5·4	34	nil
Indophos	9	80	5·5	47	nil

When comparing different basic slags it has been found that the percentage of phosphoric acid soluble in 2 per cent. citric acid does give a fair idea of the probable efficiency of the slag in the field. It will be seen from the above figures that there is only a very rough correspondence between citric-acid-soluble phosphoric acid, and relative efficiency in the field of other phosphates.

The field results from bone dust and basic slag agree very fairly with the citric soluble phosphate found. The small quantity of nitrogen supplied by the bone dust does not appear to have increased the efficiency of the manure greatly. The Algerian phosphate, however, giving only 45 per cent. as much citric soluble phosphoric acid as basic slag, showed 85 per cent. as high efficiency in the field as did basic slag. The nitrogen present in the Algerian phosphate was due to accidental admixture of 1.8 per cent. nitrate of potash. It is very improbable that this small admixture can have increased very greatly the manurial value of the Algerian phosphate. A fresh sample of the Algerian phosphate, uncontaminated by nitrate of potash, gave the same percentage of available phosphoric acid as the contaminated sample. However, the admixture makes the field result from Algerian phosphate open to doubt.

The low percentage of citric-acid-soluble phosphoric acid in Belgian phosphate is very striking for a manure of such high efficiency in the field. Plutophos provides double as much phosphoric acid soluble in citric acid as does Belgian phosphate, but shows only half the efficiency in the field. The efficiency of the Belgian phosphate is no doubt greatly increased by its relatively high acidity reducing power, since reduction of the acidity of the acid soil on which the trials were made has a great good effect on the growth of the leguminous plant used, *mati kalai* (Phaseolus spp.) Radiophos, Indophos, and the Singhbhum phosphate, all of which have a practically negligible efficiency in the field, show both very low citric soluble phosphoric acid, and very low acidity reducing power. These two tests together, therefore, may be of some value in enabling us to pick out, by laboratory tests alone, mineral phosphates which are likely to have no value on our acid soils, for the purpose of growing a green crop; but on the whole it can be said that only field trial can give reliable measurements of efficiency.

Superphoshate, which has no acidity reducing power as measured by the method used, might be expected to be un-

suitable for use with leguminous crops in acid soils. The field trial, however, shows it possesses a fairly high efficiency in increasing growth of *mati kalai* on an acid soil.

Although superphosphate has no power of reducing the acidity of a simple strong acid, it actually reduces the acidity of the complex mixture of substances in the soil. This is explained through its power of combining with and rendering insoluble the more soluble of the complex aluminium compounds which are responsible for the mineral acidity of North-East India tea soils.

Superphosphate of course reduces acidity much less than basic slag, and it is for this reason only that it proves less efficient than basic slag on acid soils.

Previous trials have shown that when used with lime it is exactly as efficient as basic slag.

In addition to chemical properties, fineness of division is always a big factor in determining the availability in the soil of an insoluble phosphate. In all the above materials grinding had been so fine that the use of sieves fails to show up the number of extremely fine particles present. Hall's method, which is used to separate soils into particles between certain limits of size, was therefore adopted for the separation of different sized particles of these manures. Particles of the size of "clay" and "fine silt" were estimated together Distilled water was used for the flotation instead of dilute ammonia.

		PARTICLES OF DIAMETER IN MILLIMETRES.			
Per cent.	Moisture.	1 to ·2 "Coarse sand."	·2 to ·04 "Fine sand."	·04 to ·01 "Silt."	Below ·01 "Fine silt and Clay."
Basic slag	1·[illegible]8	24·8	52·1	10·5	9·6
Bone dust	10·86	58·2	19·6	2·9	4·5
Algerian phosphate ...	7·56	6·9	54·3	24·1	3·0
Belgian phosphate ...	0·74	nil	98·3	0·5	0·4
Plutophos	1·16	31·7	45·8	8·3	13·0
Radiophos	2·94	29·1	45·8	11·0	10·4
Indophos	0·46	3·50	67·6	13·5	14·7
Singhbhum phosphate ...	0·36	nil	55·3	23·0	20·6

The whole of each sample passed a one millimetre sieve. The "coarse sand" is the amount which fails to pass a sieve of about 100 meshes to the inch. The other fractions were determined by flotation.

Algerian phosphate and bone dust contained a little water soluble matter.

The Belgian phosphate is remarkably even in the size of its particles, practically all falling within the range of fine sand. This makes it extremely easy to handle, since it "runs" very freely. It contains practically no very fine particles, but judging from its efficiency in the field, particles of fine-sand size appear to be sufficiently small. The Singhbhum phosphate is beautifully finely ground, it feels between the fingers almost as an impalpable powder. Indophos also is very finely ground. Very fine grinding is, obviously, not enough to render such insoluble materials efficient as quick-acting manures.

ANALYSES OF SOILS AND MANURES.

Since the abolition of the analytical branch in 1914, the whole time of the staff of the Chemical Branch is occupied in research, and analyses of soils or manures for the benefit of individual gardens cannot be undertaken by this Department. Arrangements have been made that such analyses will be made by Calcutta analysts, strictly according to methods laid down by the Chief Scientific Officer.

Before being placed on the Indian Tea Association list, all analysts have been interviewed, and their laboratories inspected by the Chief Scientific Officer.

Each analyst, also, analyses a check sample of soil, sent annually from Tocklai, and reports results to the Chief Scientific Officer. These results are compared with previously ascertained correct results, and any disagreement is reported to the analyst concerned, who is asked to check his method.

These precautions ensure that results obtained by analysts on the Indian Tea Association list may be relied upon. The following analysts are now on the Indian Tea Association list and will carry out full analyses of soils for a fee of Rs. 56 per sample.

1. Messrs. Bird & Co.,
   Research Department,
   Chartered Bank Buildings, Calcutta.
2. Messrs. R. V. Briggs & Co.,
   8/B, Lall Bazar Street,
   Calcutta.
3. Messrs. J. & R. Hutchison,
   1 and 2, Hare Street,
   Calcutta.
4. Messrs. Smith Stanistreet & Co., Ltd.,
   18, Convent Road, Entally,
   Calcutta.
5. Messrs. D. Waldie & Co.,
   1, British Indian Street,
   Calcutta.

The analyses, when obtained, should be sent to the Chief Scientific Officer, who will report upon the quality of a manure, or on the probable agricultural value of a soil, and suggest correct manurial and other treatment for it.

Samples of soils or manures should not be sent to Tocklai unless asked for for purposes of research.

Method of taking Soil Samples.

Soils in North-East India vary greatly from place to place and a single piece of earth cut from one place, can only by accident truly represent the section from which it was taken. Manures also are not always evenly applied, and such a single piece of earth may include, for example, a lump of lime, or of animal meal, so that the analysis might give a very wrong idea of the real average soil.

The bulk sample sent for analysis should always be a mixture of a number of small samples taken in different places.

The following procedure is recommended :—

Select a patch of soil of about 20 yards square, which appears fairly to represent the section to be sampled, in colour and texture, and in size and health of tea bushes.

Within this area samples should be taken from at least ten different points.

Generally a sample of surface soil only, to 9 inches depth, is required. This is most easily taken with an ordinary carpenter's auger (2 inches diameter).

This should be screwed in to 9 inches depth, withdrawn by a straight pull, and the adhering soil rubbed off into a box.

For full analysis about 2 lbs. soil are required.

A 2-inch auger takes about 1½ ozs. of soil, so that about twenty such borings will be necessary.

Sometimes surface soil and subsoil may be markedly different. A layer of clay may overlie sand or *vice-versâ*; clay or sand may overlie pêat or *vice-versâ*. In that case a sample of the subsoil should also be taken, and described, for example, thus :—

SAMPLE No 1.—Section No. 8, Top 9 inches.

SAMPLE No. 2.—Section 8, Subsoil 12 inches to 21 inches.

The earth auger may also be used to take subsoil samples. When the top nine inches has been removed in taking the sample of surface soil, the auger should be screwed in to 12 inches (or other depth at which different soil occurs), withdrawn and adhering soil thrown away. The auger is then screwed in to a further nine inches, pulled out, and adhering soil collected.

If the soil is loose and dry, it will not adhere to the auger. Samples should, for this reason, be taken when the soil is moist, or compacted sufficiently to adhere to the auger.

When a sample is taken it should always be marked with the number or name of the section from which it comes. We have on our files many analyses marked only with a letter or a number, and these are now useless to the garden concerned because no one knows where they came from.

INFORMATION WHICH SHOULD ACCOMPANY A SOIL ANALYSES.

The reason for sending the analyses should be given. It saves unnecessary writing if it is stated whether the land is virgin jungle proposed for new planting, tea in fair condition for which a maintenance programme of manuring is required, or poor tea thought to require particularly good treatment. Poor tea may be growing on good soil, or good tea on a poor soil, if well treated. The constitution of the soil is only one of the factors which affect growth.

The following information therefore should be given :—

1. Age of tea.
2. Jat of tea.

3. Distance apart of planting.
4. Notes on drainage and lie of land.
5. Pruning for last five years.
6. Manuring for last five years.
7. Yield for last five years.
8. Pests and blights recognised to be present, if any; and treatment given, if any.
9. Whether tea is shaded, and if so, kind of tree used and distances apart.
10. Condition of roots, and nature of root growth. An average plant should be taken up and described, or better still, the whole plant sent in to Tocklai.
11. Colour of soil.

If a rotation of manuring is required to be suggested the following information should also be given :—

(1) Total area to be manured.
(2) Number of acres which can be given cattle manure at ten tons per acre, or top-dressing.
(3) Number of acres which can be given quick growing green crops (*e.g.*, cowpeas, dhaincha, sunn hemp).
(4) Number of acres which can be given semi-permanent green crops, *e.g.*, Boga medeloa, Arhar.
(5) Price at which oilcake is obtainable, locally.
(6) Amount per acre proposed to be expended annually in manuring.

AN OUTBREAK OF BLISTER BLIGHT IN THE SURMA VALLEY.

By

A. C. Tunstall.

In the cold weather of 1926-27 specimens of Blister blight, *Exobasidium vexans*, Massee, were received for the first time from the Surma Valley. This disease had been reported from this valley a number of times but subsequent investigation showed that in each case the reports were incorrect. Mr. Gupta, Manager of Sabazpore Tea Estate, forwarded some specimens of the disease early in December. He reported that the disease appeared on a few bushes in two widely separated areas on his garden during the first week in December. As the fungus takes about ten days from the date of infection to produce fruits it is probable that the spores were introduced about the middle of November. Outbreaks of the disease were reported from many gardens in North-West Cachar, where it apparently arrived about the same time. Specimens were next received from the Hailakandy District and it was later discovered in the Longai and Chargola Districts of Sylhet and the Happy Valley District of Cachar. It would appear, therefore, that the disease is distributed all over the North of the Surma Valley.

The writer visited many of the gardens concerned and endeavoured to trace the origin of the outbreak.

Seed.

Attention was given to the possibility of the disease arriving from other infected areas in consignments of seed. In none of the cases investigated, however, had any seed been imported from infected areas for over a year previous to the appearance of the disease. The distribution of the disease on the individual gardens also did not favour the suggestion that the spores were introduced with seed.

Climatic Conditions.

A comparison of the climatic conditions with those of previous years showed no striking differences. It did not appear probable, therefore, that the disease had been present for some time and had only attacked the tea, because of exceptional climatic conditions favouring the fungus. It would appear that the spores of the fungus were not present in previous years and that, somehow or other, they have been introduced recently. A study of the situation of the gardens attacked shows that, while the gardens in North-West Cachar, on the slopes of the Khasia and Jaintia hills, appeared to be attacked indiscriminately, those gardens, situated in the valleys further South, were not so attacked. Only those on the Western side of each valley were involved. The gardens to the East of the valleys were and still remain uninfected. Unfortunately, comparatively few records are kept of the direction of the wind in these districts but the Meteorological Department of the Government of India kindly supplied some data. From this data, it would appear that at the time of the year the disease appeared, the wind to the North of Shillong was from the North-East. Further South, it veered round and at Silchar, was East to North-East. In North Cachar, it was North to North-East. If the spores of the fungus were borne by this wind, it is possible to explain the appearance of the disease on the gardens to the West of the valleys concerned, as these gardens would be exposed to the Easterly and North-Easterly winds while, those situated to the East would be to some extent protected. The gardens concerned are so widely separated and in some cases so well isolated that it is difficult to account for the distribution of the spores of the fungus except by the wind. If, however, the spores came on the wind, whence did they come and why did they not come before? These questions can only be settled by a careful investigation of the jungle in the hills to the North of the Surma Valley. It is well known that another species of *Camellia, Camellia drupifera*, is present in that district and that this species is attacked by a species of *Exobasidium*, but this

fungus differs from that which attacks tea. The species of *Exobasidium*, now attacking the tea in the Surma Valley, is identical with that which is found on tea in other districts. It is, however, possible that the tea species is capable of attacking *Camellia drupifera* or some other plant present in the jungle concerned. The spores may have been carried by the wind to the Khassia, Jaintia and North Cachar hills and infected wild plants in those hills. These in turn may have acted as the centres of infection whence the present outbreak originated. It is of course possible that the spores were carried all the way from the areas previously known to be infected but this is unlikely, as, if it were possible, it is difficult to account for the fact that the disease has not been found in the Surma Valley before.

If the disease has been distributed from recently infected areas to the windward of the Surma Valley, it is probable that the disease will appear again next cold weather, whenever the wind lies in the right direction. It is, therefore, important to ascertain if possible the centres of infection and to study the possibilities of removing them. For this purpose a special tour has been arranged.

In the meantime every effort should be made to eradicate the disease wherever it is found in the Surma Valley. Whether the disease will come again on the wind next cold weather remains to be seen but whether it does or not, the eradication of the fungus actually present in the Surma Valley, should be vigorously attempted. It is unlikely that the disease will do very serious damage in the Surma Valley, on account of the temperatures in the rains being normally too high to enable the fungus to thrive. It should, however, be pointed out that the requirements of fungi sometimes change and the fungi may become adapted to changed conditions. This is readily conceivable when the enormous numbers of their spores and their rapid growth are considered. It is therefore, important to prevent the disease becoming permanently established on the tea in the Surma Valley.

The following suggestions will help the Surma Valley planters to deal with the disease.

Blister blight is caused by a fungus called *Exobasidium vexans*, Massee. This fungus only attacks the young succulent growth. It enters the leaf or green stem at the tiny openings through which the plant transpires. About 10-11 days after infection visible signs of the disease appear and "blisters" are full grown, in from 11—18 days from the time of infection. The blight at first appears as round, translucent pale yellow, sometimes pink, spots on the leaf. As the disease progresses these spots enlarge into white or pinkish, convex warts, mostly on the under-surface of the leaf. The opposite surface is pale green, yellow or pink, with concave depression. At a later stage these convex warts shrink and darken into deep brown, almost black spots, which dry up, sometimes crack and fall out, leaving round holes in the leaf.

Where the blight is observed on one or two bushes only, the safest treatment is to pluck off all succulent leaf from the bushes concerned. This leaf should not be carried about in baskets, etc., as by so doing the spores are further distributed by air currents. If the leaves cannot be conveniently burned or buried on the spot they should be placed in the nearest drains. As the spores die very quickly after the diseased material is plucked the danger of infection from such material does not last long.

Unfortunately, the disease is distributed very readily by the wind and frequently a considerable area becomes infected before attention is drawn to it.

On account of its preference for succulent growth, cut back tea is specially liable to infection and when the attack is severe, the green shoots may die right back to old wood. The removal of all succulent growth would do as much harm to such bushes as the blight, so it is necessary to apply other remedies. The best is to spray the bushes concerned thoroughly with Lime-sulphur solution. As the disease may be growing within the tissues for 10 or 11 days and the spray fluid would have

no influence on it until it is exposed (*e.g.*, in the "blister stage) it is necessary to spray more than once. I suggest weekly applications to such infected areas until there be no more signs of the disease.

Where the disease is present on considerable areas of unpruned tea, the areas concerned should be skiffed or better still light pruned and all succulent wood removed. The prunings should be burned but on no account should they be carried through uninfected areas. The whole of the infected area should then be thoroughly sprayed with Lime-sulphur solution. If all succulent growth is removed, it will not be necessary to spray again, as no leaf likely to contain the fungus will be present.

On some gardens the disease has already become general and stray blisters may be found on all sections. In these cases it is impossible to eradicate the fungus at once. I recommend the following procedure :—

1. It is very probable that the hot dry winds usually prevalent in the Surma Valley during the early part of the season will kill off most of the disease, especially on exposed areas. In damp shady places, however, the fungus may continue to thrive throughout the year. Such places should be searched at intervals and wherever the disease is found, succulent leaf should be removed and the bushes thoroughly sprayed immediately after.

2. Spray all cut back areas or other tea, likely to suffer severely from loss of succulent growth, immediately the disease appears on such areas.

3. Skiff, or better still, light prune all unpruned areas found to be infected. If it is essential to leave certain areas unpruned those areas must be thoroughly sprayed after plucking all succulent growth.

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General View of Borbhetta Experimental Station.

From South-West corner of [illegible] Plots looking to the North-East.

BORBHETTA EXPERIMENTAL STATION.

BY

H. R. COOPER.

In the advancement of knowledge of agriculture, laboratory work is very useful. Results obtained in the laboratory however have to be tested in the field before they can be relied upon.

Subjects also upon which little or no theoretical scientific knowledge exists may be studied by direct experiment in the field with results of the greatest practical value. Usually practical knowledge of the value of an agricultural operation is obtained, before its usefulness is extended and its limitations discovered by scientific investigation.

Direct field experiments can be, and are, made on tea gardens. The results obtained however cannot be relied on at all closely. When it is desired to measure the effect of one particular factor, it is of course essential that all other factors shall remain constant throughout the experiment.

No other factors affect tea crop so greatly as plucking and cultivation and it is extraordinarily difficult to keep even these operations truly constant throughout the plots under experiment. The main difficulty however lies in soil variation. However small or large plots may be made, no two adjoining plots would ever give the same yield if treated exactly alike; and, it too often happens that differences, due only to initial differences in the plots before treatment, are ascribed to the effect of treatment.

At Borbhetta the tea is planted in blocks such that in each block, tea from the same nursery is planted in the same manner and at the same time with plants of about the same vigour, both bad plants and exceptionally good plants being rejected. Following planting, treatment is very carefully kept the same, every small plot in the block for example being always plucked on the same day, by the same people, and cultivated within

two or three days at most. Pruning is kept very carefully the same from the beginning.

In about the third year the block is divided, like a chess-board, into small plots for soil treatment experiments, or into single lines for pruning or plucking experiments, and the yield from each plot or line recorded until the initial yielding capacity of each is considered to be sufficiently indicated. On tea undergoing this preparation, manuring is confined to individual treatment of infillings, bad bushes, and bad patches, in an attempt to even up the block. With all these precautions, soil variation is so great that on a block averaging 12 maunds per acre, the yield from the individual small plots may vary between 8 and 18 maunds per acre. This last difficulty is met by reduplication of plots. About five plots are allotted to each particular treatment; in which case the average yield of each such series of five plots is usually about the same within five or, at most, ten per cent. If the variation is as much as ten per cent., results from one year's experiment will be of no value; but, if the effect of the treatment is cumulative, the results obtained are reliable after a few years.

The earliest experiments were commenced without waiting for some of these precautions, because knowledge on some subjects was so urgently desired. In consequence, although indications of the very greatest value have been obtained, the actual numerical results are subject to an undesirably great probable error. Such indications are the most that can be expected from experiments on gardens, but they are still of enormous value as our only means of discovering differences in reaction of different soils in different climates to any particular treatment which has been studied in detail at Borbhetta. Without experiments on other gardens the results obtained at Borbhetta can only be applied to other gardens after considering the probable effect of difference in climate and of soil as shown by analysis. Such considerations in the absence of definite experiments on soil similar to that in question must in some particulars amount to little more than guess work. The guess however is much more

likely to be a good one when general knowledge is combined with results of accurate experiments at Borbhetta.

The land at Borbhetta is physically very much the average of the district, consisting as it does mainly of fine sand; but having been Government grazing land for a very long time, it is chemically very poor compared to the newly cleared jungle land on which most of the gardens were put out.

Three analyses of soils from widely separated parts of the area show the general characteristics of the soil. No. 1 is the average of the five unmanured check plots from the Betjan Lime Experiment block; No. 2 is the average of the three check plots from the Matelli nitrogen experiment block; No. 3 is the average mechanical analysis of the Mesai Manipuri block.

ANALYSES OF BORBHETTA SOILS.

	No. 1	No. 2.	No. 3 surface (6″ to 12″).	No. 3 subsoil (24″ to 30″).	No. 3 subsoil (36″ to 42″).
MECHANICAL ANALYSIS.					
Soluble in dilute acid ...	0·73	...	0·4	0·3	0·5
Coarse sand ...	7·54	...	5·4	5·0	4·6
Fine sand	64·44	...	51·9	49·3	45·6
Silt	11·06	...	17·6	18·2	17·8
Fine silt	8·91	...	13·4	12·8	15·1
Clay	5·94	...	8·2	11·8	13·8
Loss on ignition ...	2·44	...	2·9	2·6	2·7
CHEMICAL ANALYSIS.					
Loss on ignition ...	2·44	3·48			
Organic matter (Grandeau method)	1·16	1·16			
Acidity (Hopkins method)	565	455			
pH.	5·1	5·4			
Total nitrogen ...	0·066	0·090			
„ phosphoric acid ...	0·037	...			
Available phosphoric acid	0·0076	0·0059			
„ potash ...	0·0052	0·01421			
„ lime ...	0·0110	0·03111			
„ magnesia ...	0·0100	...			

No. 2 is an exceptionally rich, narrow neck of land between two hullahs, where it had escaped the attention of cattle sufficiently to grow fairly thick scrub jungle in place of the normal close-cropped grass. It has also received potash and phosphoric acid as manure, but no nitrogen or organic matter.

The average soil is deficient in every possible respect, and is therefore very fit for an experimental station. If for example it contained an ample supply of phosphoric acid, then the value of different phosphatic manures could not be determined on a soil on which no phosphoric acid was necessary.

The soil's poverty however makes it difficult to establish tea for experiment without using manures, and this difficulty is increased because it is impossible to use shade trees. In order to get a sufficient number of replicated experiments within the small area, plots have to be very small. A single shade tree would affect several plots, and would affect them unequally. Shade therefore would introduce a disturbing factor into the experiments and cannot be used.

Like all fine-sand soils, deficient in organic matter, the soil as the unpleasant property of forming a "steely" crust when dried after rain, and hence forms very bad seed beds. Physically however it suits tea bushes very well, and with good cultivation tea can be grown to give a sufficiently high yield for accurate measurement, particularly as there are no vacancies, and poor plants are never put out.

Leaf and stem diseases however reduce crop very considerably and in May the place has a very poor appearance unless the weather has been very favourable. By about the end of June however it has always come away and looked well till the end of the season.

Root diseases are common but the infected plant is always quickly removed.

Red spider is the only insect pest which gives serious trouble.

For labour, neighbouring villages are relied upon. We have about 50 acres planted with tea and in 1926 the average daily attendance was 70 coolies (including men, women and children) per working day. Even though we have over 800 plots to be manured and plucked separately this would be sufficient if the attendance were regular; but whereas at certain seasons there is more labour than can be economically employed, during the rains attendance may drop to 35, when the amount of cultivation necessary to young tea could not be given except by the use of buffalo-drawn cultivators, which have saved the situation. Buffalo-drawn cultivators however are undesirable in well-grown wide tea, while more pluckers are required as yields become greater. Extensions therefore can be made only very slowly, which is much to be regretted as there are many urgent questions awaiting practical experiment.*

During the cold weather 1926-27, however, about seven acres were cleared and roughly levelled.

Nurseries to plant at least part of this will be sown at the end of 1927, and meantime levelling will continue as labour is available. In levelling, all teelas and high land are cut down, and all holes and shallow nullahs are filled up. In each case the top "spit" is first cut and placed on one side to be replaced when levelling is complete, in order to get the land as even as possible for experiment.

Results of experiments have been published from time to time and it is the object of this note only to record the work to the end of 1926*, and indicate what there is to be seen to interest visitors, of whom there are not so many as we should like.

Entering by the North gate, having passed the area now being levelled for planting, there are on the right hand :—

The Rajghur Plots.—Area four acres.

These were planted, 4½ ft. by 4½ ft. triangular at the end of 1924, with one year old Rajghur plants. Up to March 1926

* For previous report see Quarterly Journal, 1918, Part II, p. 48.

the plants were left to establish themselves, and were then pruned by removal of central stems but leaving always shoots on both sides. In most cases the cut was within four inches of the ground, but if there were no low shoots the first cut was in a few cases as high as 9 inches, and, on one or two plants only, still higher. Every cut was flush with the top-most remaining shoot. The plants were then tipped for a few rounds at 18 inches to hold back shoots tending to run away. Plucking after that was at 30 inches from the ground. About one maund tea per acre was obtained in 1926. At the end of 1926 very fine wood had been grown, and the area was pruned to between 12 inches and 15 inches from the ground, each cut being made flush with an outside branch or shoot; all in-growing shoots were removed and in most cases one strongly growing, too perpendicular, central branch was taken out or cut back to a low outside branch. The bushes have already a fine spread and are free from any dead or diseased wood.

Very dry weather followed the first pruning and nearly five per cent. of the plants either died or became hopelessly debilitated by fungus disease entering at the pruning cut. These were replaced in September 1926 with two-year old plants cut to six inches in the nursery just before lifting. After they had come away the snag of dead wood was cut flush with the topmost shoot. Very good weather followed the infilling and all are doing remarkably well.

In 1927 plucking will be at 30 inches. A yield of about 4 maunds is expected.

This area will be divided into small plots for separate plucking in 1928.

At the end of 1926 it was debated whether it might not be better to leave unpruned with a big leaf area to force root-growth. It was decided that it was better to avoid badly healed pruning wounds by cutting on one-year old rather than two-year old wood, but the small area at the west end, cut off by a *hulluh,* has been left unpruned in every other line, the alternate lines being pruned

as described. Each line will be separately plucked and weighed over a series of years, and the advantage or otherwise of leaving unpruned at this stage thus accurately determined.

Turning to the right, and keeping the Rajghur block on the right hand, there are on the left :—

The Betjan Lime-Experiment Plots.

These occupy a block of 3.2 acres, but as two lines in every ten were left for paths and drains, the actual area under tea is only 2.6 acres.

This was planted 5 ft. by 5 ft. triangular in March, 1919, with 15 months old Betjan plants. In March, 1920, they were pruned exactly as the first pruning described for the Rajghur plots; but in order to get, quickly, yields large enough to allow the plots to be used for experiment, the second pruning at the end of 1920 was at 20 inches from the ground, the strong centres being taken out. Thereafter ordinary top pruning was applied. Big early yields were successfully obtained, and the bushes now cover the ground completely,—the unmanured check plots have given annually between 12 and 13 maunds for the last three years—but as a general principle this high cut on weak outside branches is clearly a mistake. Many of the outside branches are very weak and have become badly attacked by red rust and other stem diseases, while in 1927 the bushes are already as high as is convenient for plucking.

However in 1921 an average of 5.2 mds. tea per acre was obtained and in 1922 experiments were started.

The rise in crop due to increasing maturity was so rapid for the next few years that it is very difficult to calculate with any degree of accuracy the exact effect of the lime added.

These experiments were started far too early. However the figures show clearly enough that the effects from the quantities of lime added, are very small, and that such effect as there is reduces crop slightly. This was the more surprising since the soil of this block is so acid that even cowpeas, which are not sensitive to acid conditions, benefit very greatly from liming. The Rahar

planted in 1925 would not grow at all in the unlimed plots, but increasing quantities of lime gave rapidly increasing crops.

It was observed that the greater the crop of Rahar, the greater was the loss of tea crop. The loss amounted to about 13 per cent. for every hundred maunds of Rahar per acre.

Samples of soil from the plots are analysed from time to time, to note changes in acidity and lime content with time and treatment.

Next to these Betjan Plots are ;—

The Bazalony Plots.

This is an area of exactly the same size and plan as the Betjan plots, and was put out with plants of the same age at the same time as the Betjan plots, and the pruning treatment was exactly the same.

This variety, however, grew very much more poorly, and has given much smaller yields. However, after a lot of manuring and extra cultivation the tea was sufficiently well established to be assigned to plucking experiments in 1924. It was divided into 64 lines of 80 bushes each. Yields were recorded for each line under the same plucking during 1924, 1925, and 1926, after which they were divided into 16 sets of four lines per set so that each set had given practically the same yield in 1925 and 1926.

In 1927 different systems of plucking are being tried on each set, and it is expected that the results will prove to be accurate. On this subject information will be very valuable.

Next come :—

The Suffry-Lushai Plots.

This is a block of 3.6 acres reduced by the missing of every tenth line for path and drain to 3.2 acres of tea. It was planted five feet by five feet triangular early in 1921 with year old plants from seed from the Lushai seed-bari at Suffry. At the end of 1921 the plants were considered too weak for any prun-

ing, but during 1922 were plucked at 28 inches to prevent strong shoots from running away, yielding .85 mds. of tea per acre. In 1923 they were left unpruned and plucked over two new big leaves yielding 3.9 mds., after which they were cut across at 18 inches, and centres taken out as low as possible to leave fairly stout frames without much spread. In 1924, 5.7 maunds were obtained. In 1925 pruning left four inches new wood, and the yield was 7.3 maunds. In 1926, after pruning to one inch new wood, the yield was 11.2 maunds.

By this time the bushes had filled up and the yield probably become steady, but the increases for individual plots in 1926 compared to 1925 were too great and too uneven to allow these plots yet to be placed under experiment. It is hoped that they may be used in 1928.

It is, at present, proposed to use them to determine the best time of year for application of single doses of the commoner manures, a point on which information is badly needed.

Next come the—

Burma Nitrogen Experiment Plots.

These are on a block of four acres, reduced, by leaving every tenth line for drains, to 3.6 acres.

It was planted at the end of 1920, five feet by five feet triangular, with one-year old Burma plants. The nursery, having been made in a favourable year, was a particularly fine one. At the end of the year there were only half a dozen vacancies, and only three plants have died since. This very hardy variety is particularly suitable for experimental plots. Very few outstandingly good plants are produced, and practically no bad ones. It yields well but the shoots are relatively small and take a long time to pluck.

At the end of 1921, the young plants were centred as low as possible, the few single stemmers being cut at one foot from the ground. In 1922 plucking was at 27 inches and .8 maund per acre was obtained.

In 1923 the bushes were left unpruned and plucked at 30 inches, after the area had been divided into 80 small plots of 90 bushes each. The average yield was 6.1 mds. Among the 16 series of five plots the average variation from the mean yield was three per cent. and the maximum variation less than eight per cent. Such an even block was thought good enough to start experiment on. Later experience has proved that accuracy of results would have been increased by waiting.

However, early results were wanted and not much has been lost in accuracy.

In 1924, after pruning to 20 inches, quantities of nitrate of soda to provide from 15 up to 120 lbs. nitrogen per acre were applied both in single and in divided doses, and with and without potash and phosphoric acid. The average yield of the whole block was 7.8 mds. The average of the five unmanured plots was 7.75 mds. and the most expensive manuring yielded 7.9 mds. The closest examination of the figures could reveal no effect whatever from any of the systems of manuring tried. The same nitrate of soda (which had been shown by analysis to be nitrate of soda containing 16 per cent. nitrogen) also showed no effect in 1924 on plots where other consignments of nitrate of soda had given results in 1920, 1921, 1922 and 1923 and did again give results in 1925 and 1926.

The assumption must be made that the 1924 consignment contained some impurity which destroyed its efficiency. Unfortunately no sample had been retained so that the nature of the impurity might be discovered.

In 1925 and 1926 the tea was top pruned and the same systems of manuring as in 1924 applied with great success.

In 1925 the unmanured check plots gave 8.6 mds. while the most expensive manuring gave 11.3 maunds.

In 1926 the unmanured check plots gave 10.4 mds. while the most expensive manuring gave 15.9 maunds.

The cost of the most expensive manure was Rs. 100 per annum exclusive of cost of freight and application in eight doses.

If the manured plots go on gaining at the rate of 2.7 mds. per annum, then in 1929, the check plots will probably have reached their maximum at about 12 mds., while the most heavily manured plots will have reached 25 mds ! It will be very interesting to see whether this rapid rate of increase is obtained, and if so, for how long !

When the factory is going it will also be very interesting to see what difference in quality appears.

It is probable that some intermediate quantity of manure will be found best.

Turning back along the same road there are on the left hand :—

The "Cultivation Experiment Plots."

These consist of 3.5 acres of Singlo Tea and 3.7 acres of Matelli Tea, but the areas have been reduced to 2.8 and 3.0 acres respectively by the removal of two lines of tea from every ten to put in drains. Drains had originally been put in at 50 feet apart without leaving out tea, so that drain edges were about two feet from the collars of the bushes. The care of drains on this sandy land was not then well understood : the drain sides were scraped and the result was that they fell in, taking very large numbers of bushes with them. To save further trouble, in 1918, a line of bushes on each side of each drain was removed and drains left six feet wide at the top sloping to one foot at the bottom. The drain sides give no further trouble in falling, but the cutting of the thatch on them takes a lot of labour, and this thatch is continually invading the planted area, while the drain-side bushes suffer badly from over-dry soil.

On previously undisturbed soil drains hold up very well, if nine-inch strips along the edges are not hoed but merely sickled. In places where holes or hullahs were filled in, however, drain sides are always falling and have to be slightly sloped and revetted. This revetment, in labour and bamboo, has cost about Rs. 10 per acre annually, but it is hoped that as the soil consolidates the need for this work will decrease. Planting the

drainsides with Clitoria cajanifolia has been tried. This plant is eminently suitable for such purposes. It is a leguminous plant which will stand any amount of cutting, and both roots and stems branch and spread very well. It holds up the surface excellently, but keeps narrow drains so wet that the sub-soil caves in worse than ever.

The greater part of this area was planted at the end of 1916, and the remainder mainly in 1917, and a little in 1918. They were all allowed to grow untouched until March 1919 when all plants which were ready were collar-pruned, and the remainder were collared as soon as they reached 1¼ inches in diameter.

In 1920 the area was left unpruned and such plants as were fit for it were plucked at 27 inches. The 1916 planting gave about four maunds per acre, but the yield from the later planting varied from a quarter of a maund to two maunds in various plots.

In 1921 the area was again unpruned but plucked at 30 inches. The 1916 plantings gave on the various plots from six to seven maunds, and it was decided to place these under experiment. The later plantings were left to wait to become more even. It is a pity that all plots were not so left, but information on cultivation was badly needed.

In 1922 the whole area was cut to 8 inches from the ground. Yields under different cultivation varied from two to four maunds.

In 1923 it was again unpruned and different systems of cultivation yielded between 4 and 14 mds.

In 1924 it was cut to 12 inches, and yielded from 1½ to seven maunds.

In 1925 it was cut across at 18 inches, and yielded from 2½ to nine maunds.

In 1926 it was top-pruned leaving one inch new wood and yielded from 2.7 to 11.7 maunds.

A full account of the results of these experiments will be published in the next issue of this Journal.

These plots are very well worth seeing, and the results are of very great importance. Speaking generally, it may be said that of any two systems of cultivation, that which keeps down jungle better gives the better results and that other factors are of minor importance.

The system of pruning used is not recommended by the writer. The secondary growth from a collar-pruned bush does not appear to remain equal in vigour to the naturally grown branches. In addition, the snags left after the eight inches cut in 1924, were not removed until two years later because of the intervening unpruned year. This has left the bushes full of unhealed wounds through which, in many cases, fungus diseases have entered. The yields, even from exceptionally well cultivated, 1916-planted plots are disappointing, although the bushes, particularly the dark leaf Matelli, are of a shape which is much admired, and look well.

Having passed the cultivation plots, a road turning to the left, has on its right hand :—

The Kharikatia Plots.

This is an area of 1.45 acres reduced to 1.3 acres by missing one line of tea in ten for drains.

It was planted in the rains of 1919 with rather poor 2½ year old Kharikatia plants (Singlo once removed) which were planted uncut.

It grew poorly, and at the beginning of 1921 was cut across at 18 inches and plucked at 27 inches, yielding 1.7 mds. per acre. Since then it has been merely top-pruned with very little thinning out.

Although the yields were so poor they were fairly even, and in 1922 the area was divided into 58 small plots which were treated with different forms of lime, phosphoric acid and potash singly and in every possible combination. Each treatment was repeated on five plots, while five plots were left unmanured.

The single manures were also applied on the fallow plots adjoining, which are kept always clean of any growth.

These experiments were started not so much to observe the effect on the tea, but to observe the effect on the soil in consequent changes of the soil's acidity and nitrate content, for which purpose samples from each plot, both fallow and cropped plots, were taken weekly. One hundredweight of pure lime per acre has been added annually and other manures in quantity to be exactly equivalent to that quantity.

The potash salts have been found to cause a small but hardly significant increase in acidity. Nitrate of potash has not decreased acidity as it does on soils of high lime content. Both basic slag and, of course, lime have gradually decreased acidity very greatly. Superphosphate has also decreased acidity slightly but quite significantly.

Contrary to expectation neither lime (in the quantity applied) nor phosphates had much influence on the nitrate content of the soil. Potash increased nitrate formation quite significantly, but had only a small influence on crop, although the addition of nitrate of potash gave a very definite crop increase.

Both lime and phosphoric acid have very slightly reduced crop on this soil.

Except on the nitrate of potash plots, no nitrogen had ever been applied. As it was thought possible that extreme deficiency in nitrogen might account for the failure of the mineral manures, it was decided to apply, in 1926, 30 lbs. nitrogen annually to all plots except the nitrate of potash plots. It is too early to report results.

It is interesting to note that the check plots which had never received any manure till 1926 gave 10.7 maunds in 1926, while the nitrate of potash plots which had received nitrogen annually gave 13.5 maunds. This tea has not been collar-pruned nor shaped in any way. Its appearance has nothing to recommend it but its yield may be instructively compared to that of the similarly cultivated, but annually manured, adjoining Matelli tea planted three years earlier, which having been collar-pruned in 1919 and cut low 2½ years later, looks very handsome but yielded in 1926 only ten maunds.

The chief interest of these plots lies in the results of the determinations of nitrate in the soil.

The fallow plots were found always to contain very much greater quantities than the adjoining cropped plots. The fallow plots are obviously much the more exposed to loss of nitrates by washing out, while the quantity of nitrate taken by the crop can be estimated fairly closely and accounts only for a very small part of the difference found.

The only explanation of the difference which can be suggested is that the mere presence of a growing plant in the soil very greatly reduces the rate of formation of nitrate (the solúble form of nitrogen directly available to plants as food), from the insoluble (and therefore unavailable) forms of nitrogen naturally present in the soil as plant and animal residues.

This theory applied to tea means that the presence of jungle starves the tea bush not only by taking food which the tea might have got, but also by reducing very greatly the rate of formation of fresh plant food. Incidentally, of course, a thick cover of plants insures the soil against rapid deterioration in nitrogen content. Hence the richness of soil newly cleared from jungle and its rapid deterioration under good cultivation.

Under this theory, ideal cultivation should aim at getting the soil completely filled by the roots of tea, but with no other plant present; so that as much as possible of the nitrates which are formed are taken by the tea and sold as leaf, while loss of nitrogen by washing out is reduced to a minimum by the close cover of tea.

Having passed the Kharikatia Plots, turning to the left, there are immediately on the right four small plots which though not, strictly speaking, experiments, are intended eventually to be demonstrations on a very small scale of doing without cultivation altogether, following the above theory.

Two of the plots were planted with two-year old plants taken from the fallen drain sides of the Matelli cultivation plots in 1918. As they were not used for any purpose these odd plots

did not receive much attention and in 1923 were not very good. However, during 1924 and 1925, they were very well cultivated and manured, lightly plucked, and pruned for spread.

During 1926 they were hand-weeded only, and yielded 15½ maunds. The intention is to reduce the hand-weeding as the cover provided by the tea becomes greater, until no weeding at all need be done.

The other two small plots contain tea planted in 1925, which having been well hoed in 1925 and 1926, is now being hand-weeded only to determine the cost of this operation on tea not providing much cover.

On the opposite side of the road is a strip of about an acre in area forming part of—

The Matelli Nitrogen Experiment Plots.

These are twelve plots planted at the same time as the Matelli cultivation plots and always pruned similarly.

Calcium cyanamide, fish manure and animal meal are under trial, each being applied to three plots, while three check plots are kept unmanured. These trials have been in progress for four years, but while all manured plots show benefit, the fact that the tea has been unpruned and cut on two-year wood during the experiment has made yields so irregular, that differences between the three manures cannot be accurately measured yet. It is quite possible of course that there is no difference, but the experiments are not yet accurate enough to prove that.

The light leaf Mesai-Manipuri plots.

On the other side of the road, are thirty-eight small plots of tea covering nearly an acre. Thirty-six of them were planted with six-months old light-leafed Mesai-Manipuri tea in 1920. These were placed under a manuring experiment in 1922 and 1923, but the results were subject to such a high degree of error as to be useless. Since then, the tea has been manured to even up the plots, and may be again under experiment in 1929.

Behind these plots is a half-acre strip of land sloping down to a hullah. This was planted early in 1927 with one-year old,

very good Dhoolia plants, which are intended for small scale demonstrations of pruning.

Past the Mesai-Manipuri plots and still on the right hand side are the remainder of the *Matelli Nitrogen Plots*.

These consist of 18 plots of $\frac{1}{50}$th acre. They were planted 1916, collar-pruned 1918, unpruned 1920, and top-pruned since. Experiments with nitrate of soda, sulphate of ammonia, oilcake, nervox and green stuff were started in 1920. Although the tea was young and the plots very small the pruning was such that yields were fairly constant.

These experiments were intended only as small scale preliminary experiments, but have proved accurate enough to indicate fairly well the relative values of the manures. For several years the quick-acting soluble manures were greatly more efficient than the organic manures, but these latter are now catching up. Sulphate of ammonia still retains a lead, although (or perhaps because) it had increased the soil's acidity from 450 to 650 (Hopkins Method), after the first four applications.

The most interesting information obtained from these plots is that the effect of manuring has been cumulative, so that while one dose of manure by producing for example a gain of—say—eight per cent. over the check plot, hardly paid, yet five annual applications put the manured plot 40 per cent. ahead of the check plot.

All the plots are now seriously attacked by a fungus (Poria spp.) which entered at the wounds left by the collar pruning. This has reduced the vitality and yielding capacity of all plots, but they still serve to show the effect of the manures.

Turning to the left, there is on the right hand some land; part of which is always under nurseries. After lifting the plants, the land is treated and used again three years afterwards. Further on is half an acre planted with one-year old Dhoolia plants in December 1926. Passing over the main road, and

carrying on past the west end of the Burma Nitrogen plots, there are on the right hand :—

The Dark leaf Mesai-Manipuri Plots.

This is an area planted 4½ by 4½ with one-year old plants at the end of 1922. It is an area of 3.1 acres reduced by leaving out one line of tea in ten to 2.8 acres. The lines were left for drains, but they were not made, and the area being very flat and having deep hullahs on three sides, shows no sign of deficient drainage. This tea was allowed to grow untouched for two years, when it was cut across at 18 inches, and lightly centred at the end of 1924. In 1925 it gave 4.4 maunds tea per acre, and after top-pruning 7.4 maunds in 1926.

The bushes have a very fair spread, and are expected to yield very well, although their shape is not very handsome. This is a very old-fashioned type of pruning, which does very well in practice, and has the great advantages of not requiring a high degree of skill from the pruners, and not causing the death or serious weakening of a single bush.

Behind the Mesai-Manipuri are—

The Lushai Hill Plots.

This is an area of .9 acre reduced to .8 acre by leaving one line in ten. It was put out at the same time as the Mesai-Manipuri and has been treated similarly since, but this delicate variety yielded only 2.3 maunds and 4.7 maunds in 1925 and 1926 respectively.

Turning back east from the Lushai Hill tea there is on the right hand side a small seed garden. This was planted in 1922 with plants selected from the nursery such that all the plants had leaves of the same average length and breadth.

In 1924 the leaves were measured again and found to have changed greatly.

Plants with leaves having respectively maximum, mean and minimum ratios of breadth to length were taken up and replanted in three widely scattered places. Since replanting, the ratios

of length to breadth of leaf have again changed. The ratio of length and breadth of leaf clearly is not a fixed characteristic.

South of the road past the seed garden and across a *hullah* is three-quarters of an acre of tea put out from the same nursery as the Burma nitrogen plots. After an extra year in a congested nursery however the plants had deteriorated, and the stems were very hide-bound and attacked by stem diseases.

This area was planted in March 1922, part with plants which had been collar-pruned in the nursery the previous September, and part with uncut tall plants, which were notched about four inches from the ground a year later. The latter grew poorly and only about 65 per cent. threw shoots from below the notch. After a dressing of cattle manure those which had thrown low shoots were cut back to these shoots and the remainder collar-pruned in 1923. Meanwhile the plants which were cut in the nursery were being plucked unpruned. Both were cut to eight inches in 1925 and to 12 inches in 1926.

	Yields mds. tea per acre.		
	1924.	1925.	1926.
Collar-pruned in nursery ...	3.6	1.6	3.6
Notched after planting ...	3.4	1.3	3.2

These are very poor yields but the tea looks fairly well and will come on.

Next there are four small plots put out in 1922 with one-year old and two-year old Burma plants, in alternate lines. At the end of 1923 (when no difference could be detected between the plants of different ages) all plants were cut across at 18 inches and lightly centred.

During 1924 and afterwards two plots have received a deep hoe, followed by a round of forking, and six light hoes annually. The other two plots have received 21 rounds of the buffalo cultivator, one round of forking, and no other cultivation whatever. This cultivation maintains clean soil between the bushes,

but jungle grows badly in the bushes. The bushes, however, have suffered little relative deterioration.

	Yields mds. tea per acre.		
	1924.	1925.	1926.
Buffalo cultivated	3.4	4.9	7.1
Hoed	3.1	4.6	7.0

The hoed plots are gaining and are certainly looking better, but it is interesting to see what the buffalo can do, at less than half the cost. Except on these plots, areas under buffalo cultivation receive a deep hoe after pruning, followed by a round of forking, and an extra forking in the rains. In addition a man with a hoe, at a task of one acre, gives a cut at the roots of clumps of coarse grass, once a year in the rains. With this help the buffalo-drawn spring-tine cultivator does very well indeed.

All the tea planted in 1922 and since, still gets this cultivation only, and all the tea on the station had it from 1919 onwards, until the tea grew too great a spread after which three to five rounds of hoeing annually keep it clean.

The Tingamira Plots.

Next comes the 11.3-acre block of Tingamira tea planted 4½ by 4½ triangular. Planting started at the east end in November 1921, and finished at the west end in March 1922, all from the same year-old nursery.

The 8.3 acres (reduced to 7.5 acres by drains) at the west end was not pruned till it had been three years in the soil, because owing to labour difficulties it could not be done in the previous year. All but a little over two acres (nett) was cut down at the end of 1924. An experiment at Tocklai on plants two years in the soil had given excellent results from cutting at six inches from the ground, the new shoots arising from very close to the cut. This method tried on the thick plants which had been three years in the soil, failed, in that new shoots arose from low down, and a very poor job could be made of attempting to cut out the thick snags. However white ants appear to be finishing off the work very well.

Very good growth was made and the area yielded 3.4 mds. plucked at 28 inches in 1925, and left very thick, well-spread wood which was cut to 12 inches from the ground at the end of the year. In 1926 it came away well but soon ceased to grow and lost most of its leaves from the obscure disease "rim blight." Plucking was stopped until growth came though, and was very light for the rest of the season, partly because there was not enough labour to pluck it regularly. It yielded only 2¾ maunds, but looked very fine at the end of the season.

The two acres in the middle were so poor that they could not be cut down. It was on a patch of extremely poor "busti-site" soil. This was cut across at 18 inches and centred lightly at the end of 1924.

It gave 5.1 maunds in 1925, and 3.9 maunds in 1926 (after being very lightly plucked) after receiving five tons cattle manure per acre in each year. It is improving but is still full of stem diseases.

It has now had another five tons cattle manure per acre all over, and extra manure at the rate of 15 tons on the worst patches. In 1927 it will remain unplucked after top-pruning.

The three acres at the east end of the Tingamira block were collar-pruned at the end of 1922, after two years in the soil. It gave 1.9 maunds in the following year (1924), 10.5 maunds unpruned in 1925, and 5.1 maunds after cutting to eight inches in 1926. It is on a good piece of soil and has given no trouble, up to the present.

Behind (south of) the three-acre Tingamira Block is about ¾ acre of wild Indo-China tea. A little seed was sent by the French Government and planted at Tocklai, and from this nursery eighteen bushes were planted in the Tocklai Specimen Plots. They grew extremely rapidly and after two years in the soil averaged about 12 feet in height, or about twice the height of the best indigenous variety under the same treatment. By this time they had flowered profusely and were covered with seed. Before collar-pruning this seed was collected, and from it this ¾

acre was put out at Borbhetta early in 1923. This grew so well that it was collar-pruned, after one year in the soil.

In 1924 it gave 3.4 maunds, in 1925 (unpruned) 9.6 maunds; and after cutting to eight inches, 5.4 maunds in 1926.

In appearance it resembles a remarkably good broad-leafed hybrid. The first flush is generally red, and the old leaves often ripen red like an apple. The flower is very large, and even on plucking tea, is produced in profusion. When this block was unpruned in 1925, the seed was plucked and put in a nursery, which a year later gave very thick plants, averaging five feet in height. Even in the nursery, it flowers.

Except for marked liability to attack by red spider, it appears to be very hardy, and on that account is being tried in the Ranchi district.

Besides what has been mentioned there are one or two small plots of interest, for example, trials of collar pruning in every month of the year; trials of planting with and without a clod of earth about the roots of the young plants: trials of very large quantities of mineral manures, in order to watch the effect of extreme doses first on green crops and later on tea.

Trials of manures for green crops have given most valuable results and are still going on.

The yields of tea per acre reported must be taken as comparative only. They are calculated by taking a quarter of the actual weight of green leaf. This is too high a fraction even for really fine and close plucking such as is practised. The actual tea made would probably be nearer to 22½ per cent. of the green leaf weight. The yield also is exaggerated because it is calculated from the actual area completely occupied by tea. Thus if, in ten acres, one line of tea in ten is not planted but left for a drain, the area for purposes of calculation is taken as only 9 acres.

The method of taking the yield to be a quarter of the green leaf weight, however is very convenient, and perfectly accurate for comparative purposes.

WEATHER RECORDING INSTRUMENTS.

BY

C. J. HARRISON.

Even the most superficial study of weather conditions requires the use of measuring instruments capable of a fair degree of accuracy and requiring constant care and attention. In practically every tea garden, rainfall and temperature records are kept, while in many withering houses and fermenting rooms the humidity of the air is recorded regularly. It is seldom, however, that the instruments used are of anything but a simple type, and the use of self-recording instruments is scarcely ever seen, except for recording dryer temperatures in the factory.

The advantages of self-recording instruments, capable of giving a continuous and accurate record of climatic conditions from day to day and from week to week, will be readily admitted.

It is proposed here to describe the construction of some of the commoner recording and non-recording instruments used in meteorology and to give some notes on their adjustments and maintenance.

Thermometers.

The most general type is that in which the expansion or contraction of mercury or alcohol with changes of temperature is indicated. The ordinary thermometer indicates the temperature at the time of observation, but what are known as maximum or minimum thermometers, register the highest or lowest temperature during the period between two adjustments. A simple type of maximum thermometer is that in which there is a constriction or "kink" in the tube just above the bulb (fig. I. b) so that the mercury rises in the tube as the temperature rises, but is unable to fall past the constriction. Thus the reading of the thermometer corresponds to the highest temperature which occurred since the mercury was previously shaken back again into the bulb. To adjust the

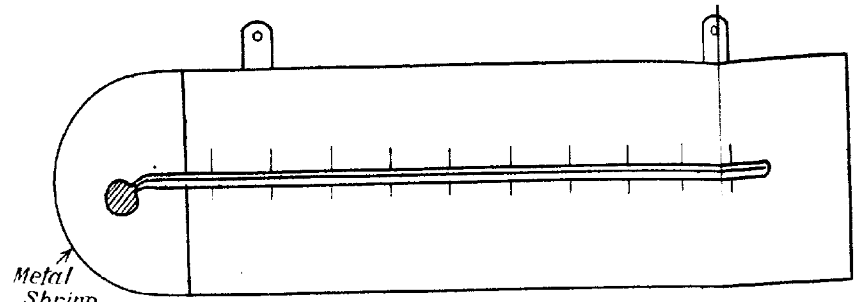
thermometer, after taking a reading, it is shaken sharply or tapped gently with the bulb downwards. The "clinical" thermometer used in medicine is of similar construction. On some instruments there is a metal spring fixed to the bottom of the thermometer to prevent fracture of the glass during adjustment. See diagram I. a.

The thermometer used for measuring the minimum temperature contains alcohol instead of mercury, the former having the lower freezing point. In the tube, and covered by the alcohol, is a small rod which is forced towards the bulb end as the alcohol contracts, but is not drawn in the opposite direction when the temperature rises. The position of the end of the float, furthest away from the bulb end, indicates the lowest temperature since the previous adjustment. The thermometer must lie in a horizontal position, and is adjusted by tilting the bulb end upwards till the rod moves to the furthest possible position from the bulb end. This is, of course, the end of the alcohol column. (fig. I. c.)

Another form which combines the maximum and minimum thermometers is Six's. This is a more convenient, though less accurate, form than those described above, and is in very general use. Figure II illustrates the Six's maximum and minimum thermometer diagrammatically.

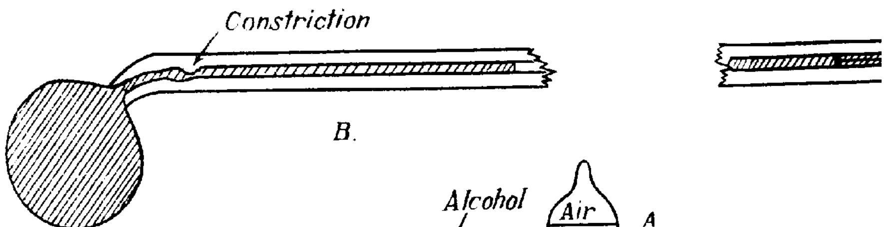
The portions AB and CD are filled with alcohol, the portion BC with mercury, while above A in the bulb is air. There are two indexes, consisting each of a piece of steel wire surrounded by glass. To the ends of these indexes are attached small feather-like springs as shown in the diagram. When the temperature rises, the alcohol in CD expands, forcing down the mercury, which in its turn pushes up the index above B and compresses the air in the bulb A. When the temperature falls the liquid contracts, and the compressed air causes the mercury column to move in the opposite direction, pushing before it the index above C. These two are therefore brought to the positions of the highest and lowest temperature, and the small spring appendages prevent them from slipping down when the mercury

Fig



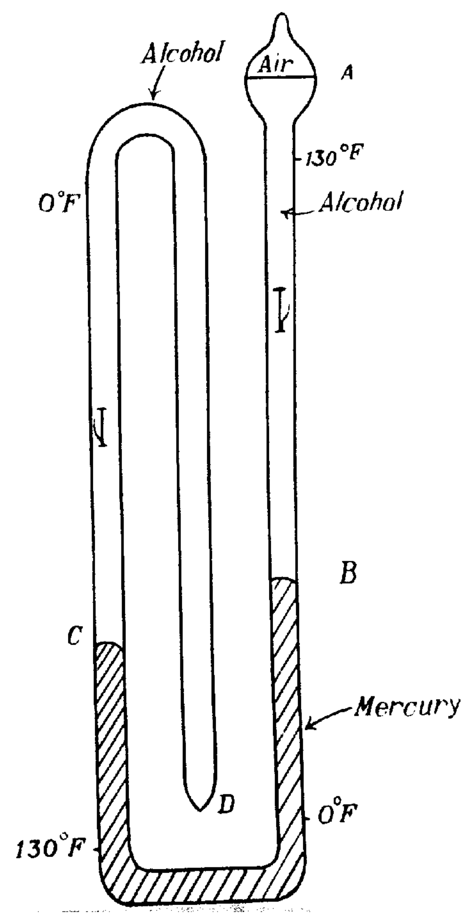
Metal Spring

A.



Constriction

B.



Alcohol
Air
A
130°F
Alcohol
0°F
B
C
Mercury
D
0°F
130°F

Fig II.

column moves away and the alcohol flows past them. The instrument is set by means of a steel magnet, whereby the indexes are brought to the two ends of the mercury column, the steel within the index being attracted by the magnet.

Recording Thermometer.

For making continuous records of air temperatures, use is made of the expansion and contraction of metal under the influence of varying degrees of heat. In one form, a metal spring is fixed rigidly at one end, the other end being attached to lever, which in turn is attached to a pointer, bearing a pen with an ink reservoir.

This pen touches and traces a line on a chart fastened round a drum which, by means of a clock, makes a complete revolution in a certain time, say in one day or one week. As the temperature rises, the metal coil expands and untwists and moves the lever attached at one end. This raises the end of the pointer on the chart and an upward sloping line is traced.

As the temperature falls the reverse of the above process takes place.

This instrument has been used for some years on an Assam garden and has given very useful data regarding variations in temperature. Such an instrument requires to be checked and set at regular intervals by comparison with an accurate mercury thermometer. Important points in the maintenance of the instrument are :—

1. To see that the chart is fixed on the drum according to instructions (printed on the chart itself).
2. To ensure that the pen just touches the chart and no more.
3. To see that all parts are clean and that surfaces bearing on each other are well oiled with a very thin oil.
4. To avoid vibration or jolting of the instrument.

A special ink, containing glycerine, is used and does not dry up quickly. The correct place for the temperature recorder is

in the thermometer box, along with the maximum and minimum thermometers. This box is described in a later paragraph.

Soil temperature thermometers.

Valuable information is obtained by taking the temperature of the soil at depths of one foot and three feet. For this purpose two ordinary mercury thermometers enclosed in wooden tubes are used. These are suspended by brass chains in brass or iron tubes sunk into the ground. The chains are attached to the caps of the tubes, as in the diagram. Over the top of the cap is placed a small wooden box (about 3 inches cube) painted white on the outside, to prevent the brass tube from heating up under the direct rays of the sun. (fig. IV.)

To read the thermometer, the box is removed and the cap pulled off quickly so as to raise the thermometer out of the tube. The temperature is read off immediately and the cap and box replaced.

These thermometers should be situated away from any wall or post which might alter the soil temperature locally. The length of the chains must be adjusted so that the bulbs of the thermometers are the required distance from ground level (either one foot or three feet).

Solar radiation thermometer.

This is really a maximum thermometer with the bulb and one inch of the stem painted dull black, and is enclosed in a wider glass tube from which the air has been drawn so as to produce as nearly as possible a vacuum. The thermometer is kept clear of the sides of the outer tube by cork rings. Fig. III. The instrument is fixed horizontally in an exposed place four feet above the ground, pointing East and West, so that the bulb is fully exposed when the sun is at its highest.

Terrestrial radiation thermometer.

This is used in conjunction with the solar radiation thermometer. It is essentially a minimum thermometer surrounded by a glass tube kept in place with a rubber ring. It is supported on a stand about six inches away from the

Fig III.

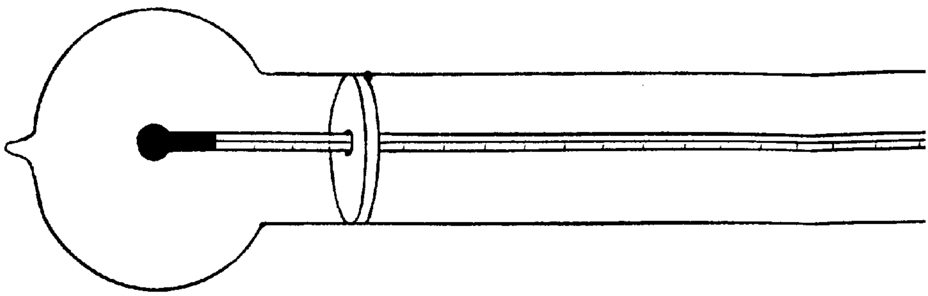
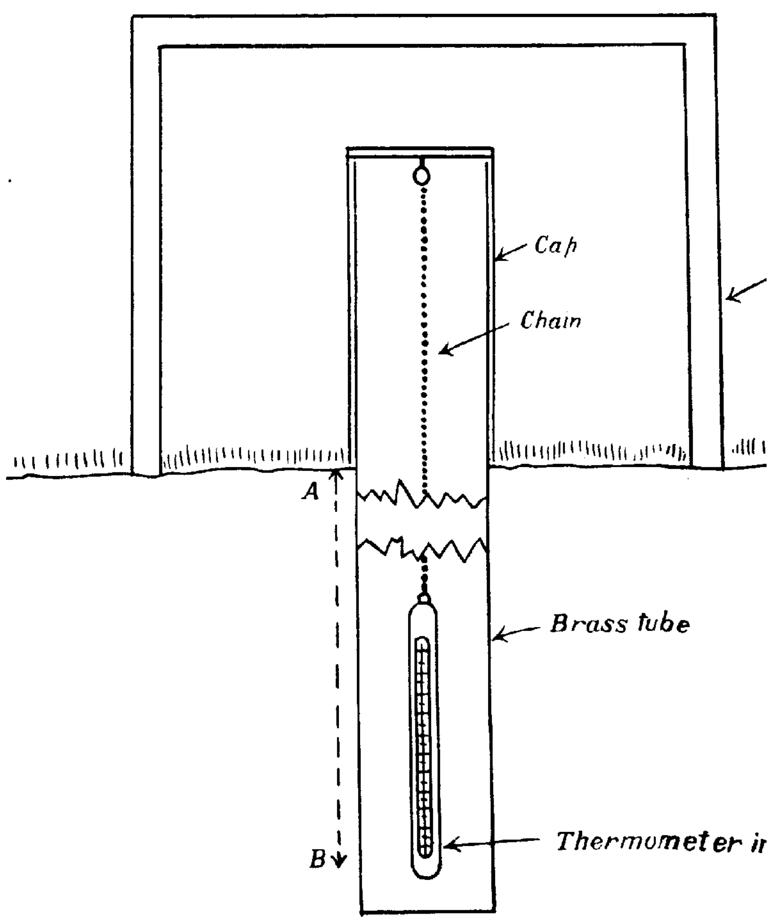


Fig IV.



ground, and is read and set, along with the solar radiation thermometer, at 8 A.M., and gives the minimum temperature just above the earth's surface in the open air. The thermometer and stand should be dried each day after reading, since moisture deposited during the night may damage the stand or cause the rubber ring to deteriorate.

A brief explanation of the value of solar and terrestrial radiation data is necessary here.

The energy radiated from the sun is practically the sole source of energy which is received by the earth's surface and is the primary cause of all climatic phenomena. Variations in the character and quantity of radiant energy result in variations in weather conditions.

This radiant energy is known as "solar radiation" or "Insolation."

The amount of solar radiation reaching a particular spot on the earth's surface depends on several factors of which the following four are the most important.

1. On the period during which the radiation has fallen on the particular place.
2. On the distance between the earth and the sun. This distance varies between 91½ million miles in January to 94½ million miles in July.
3. On the angle at which the sun's rays strike the earth. This angle for North-East India is greatest at the end of June when the sun is over the Tropic of Cancer, 23½ degrees North of the Equator.
4. On the clearness of the atmosphere.

The solar radiation thermometer is used to obtain relative values of solar radiation. The difference between the maximum shade temperature and the solar radiation temperature gives a rough measure of the solar radiation. Thus, on a day when the former reading is 85°F and the latter 130°F the solar radiation or amount of radiant energy absorbed by the earth's surface at

the particular place, is greater than on a day when the maximum shade temperature is 85°F and the radiation temperature is only 11.

We are thus able to get an idea of the heating effect of the sun on the earth's surface by studying these differences daily.

The following table shows monthly maximum and solar radiation temperatures in °F averaged for the past three years, and the difference between the two, or the relative solar radiation.

Temperature.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum	71	73	78½	81½	85¼	84½	89½	89½	88½	85	78	73½
Solar radiation ...	109	111	119½	121½	131¼	137½	139½	138	137½	130	117½	111
Difference	38	38	41	40	46	53	50	48½	49	45	39½	37½

Relative solar radiation is highest in June and July when the sun is highest in the sky, the atmosphere is generally free from cloud during the day time, and the days are longest.

During the cold weather the difference between the average minimum temperature and the average terrestrial radiation temperature, is greater than in the hot months. This difference is in part an indication of the degree of evaporation of moisture from the ground causing a cooling effect just above ground surface.

The table below compares the two temperature averages in °F for the past three years, and the differences between them.

Temperature.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Av. minimum temperature	48·5	52·5	58·5	65	70	75	75·5	75·5	74·5	69·5	59	48
Av. terrestrial radiation	44·5	49·5	56·5	65	68	73·5	75·5	74	73	67	54	46
Difference	4°	3°	2°	0	2°	1½°	0	1½°	1½°	2½°	5°	2½°

The typical Assam ground mists and fogs, and the dews generally occurring during the months October-February, are caused by evaporation of moisture from the earth, this moisture being condensed to mist or dew on meeting the cool air currents above the surface of the ground. It is during these months that the difference between the minimum and terrestrial radiation temperatures is greatest, being always above 2°F, while during the months of no mist, the differences are generally less than 2°F.

Measurement of Humidity.

The most efficient instrument for this purpose is the wet and dry bulb hygrometer. This consists of two ordinary mercury thermometers mounted on a wood or metal stand. One thermometer has an exposed bulb, while the other has the bulb surrounded by muslin which is kept wet by means of a strip of muslin connecting the bulb with a small reservoir of distilled or clean rain water. Air passing over the wet bulb evaporates moisture from it to a greater or lesser degree according to the amount of moisture already in the air. Evaporation of moisture from a surface causes that surface to be cooled in proportion to the rate of evaporation. Thus the temperature registered by the wet bulb thermometer depends on the humidity of the atmosphere. A comparison of wet and dry bulb thermometers gives information as to the relative humidity, or drying capacity of the air. If the air is quite dry the difference is great, while if the air is completely saturated the readings of the bulbs are the same, since no evaporation takes place on the wet bulb.

The relative humidity depends

1. On the actual temperatures. For the same difference in wet and dry bulb temperatures the air has higher relative humidity at higher actual temperatures than at lower temperatures.

   Thus at 80°F a difference of 5°F in the readings means a Relative Humidity of 78 per cent.

   At 90°F the same difference means a Relative Humidity of 80 per cent.

2. On the difference between the wet and dry bulbs
   At 80°F a difference of 2°F means RH=91 per cent.
   At 80°F a difference of 10°F means RH=61 per cent.

3. Barometric Pressure.

The above are values for a barometric pressure of 29.7 inches, the normal for Assam.

At a B. P. of 23.4 inches the relative humidity at 80°F for a difference of 10°F would be 63 per cent.

The following points are important in the care and maintenance of the wet and dry bulb hygrometer, whether it be used for meteorological purposes, or in fermenting rooms and other parts of the factory.

1. To see that both thermometers give the same reading when both bulbs are dry.
2. To keep the dry bulb clean and dry always.
3. To see that clean distilled or rain water only is used for the wet bulb and to see that the reservoir is clean and always filled up.
4. To keep the muslin covering to the wet bulb, and the muslin connection to the reservoir, clean, and to change it when it shows any sign of rotting or exposing the surface of the mercury bulb.

The instrument should be hung up well away from the floor, and before readings are taken it should be taken off the hook and swung gently to and fro for a minute or two, to allow the air to circulate freely round the wet bulb.

Recording hygrometer.

One type of this instrument employs the same principle as the recording thermometer, that is, the expansion and contraction of metal under the influence of heat. One metal spring is kept dry and clean and actuates a lever giving direct air temperature readings on a chart. The other spring is wrapped with muslin and is connected by muslin to a water reservoir. The lever connected to this spring gives readings on the same chart, corresponding to the wet bulb temperatures. It is usual to adjust

the levers so that, when both springs are dry, although they should actually give identical readings, the wet bulb pointer is adjusted 5°F below the dry bulb pointer on the chart. Thus adjusted, the two pointers cannot interfere with one another when the air is at or near saturation.

The same care and adjustments are required for this instrument as for the temperature recorder described previously. The situation for a recording hygrometer is on an open verandah where there is free passage of air but no actual winds, and the instrument should not be close to walls or posts.

Hair Hygrometer.

Another form of hygrometer, which can be either recording, or non-recording, is one employing the expansion and contraction of hair (human or animal) with changes of humidity. The drier the atmosphere, the shorter is the hair. A bundle of three or four hairs twisted together, about one foot in length, is attached rigidly at the upper end, and to a lever at the lower end. This lever actuates either a pointer on a dial, or an arm carrying a pen which traces a line on a chart fastened on a revolving drum. This instrument must be checked daily by comparison with the wet and dry bulb thermometers.

Adjustment is made by a screw which tightens or loosens the strands of hair.

Measurement of Rainfall.

The standard rain gauge of the Indian Meteorological Department is a cylindrical vessel, 14 inches high and five inches in diameter. The rain falls into a funnel with a brass rim which must be exactly 5 inches in diameter, and thence into a glass or enamelled jug. The quantity of rain is measured daily by pouring it into a graduated cylinder holding half an inch of rain when full, and marked off in tenths and hundredths of an inch.

The gauge should be fixed on a "pucca" base, two feet square and about two inches above the ground. The gauge is embedded 4 inches deep in the cement, so that the top of the

gauge is exactly one foot from the ground level. The gauge must be vertical and the mouth of the funnel exactly level. There should be no tree or building within thirty yards of the rain gauge, and anything which might shelter the gauge from rain when wind is blowing should be well clear of the rain gauge.

Automatic Recording Rain Gauges.

In these instruments water falls into a vessel floated on mercury. The vessel sinks gradually as it fills with water, and actuates a lever which traces a line on a revolving chart. When the vessel is full the water is automatically siphoned off into another vessel. Thus a chart similar to the one shown in the diagram is obtained. The vessel into which the water siphons is removed at regular intervals and the rain measured as a check on the recording instrument.

Sunshine Recorder.

The type of instrument used commonly for recording the number of hours of bright sunshine is a cylindrical metal box five inches long and four inches diameter, adjusted on a pedestal so that it lies pointing North and South, and is canted so that its axis is perpendicular to the path of the sun in the sky. Midway between the top and bottom of the cylinder are small pin holes on opposite sides of the cylinder, and the box is adjusted so that these holes are on the East and West sides respectively. As the sun travels from East to West during the day, the rays passing through either of the holes (the East one in the morning and the West in the afternoon) produce a bright spot on the inside of the cylinder which moves gradually round it. Sensitised paper, marked off in hours, is fixed round the inside of the cylinder, and as the spot of light travels across the paper, a dark streak is imprinted on the paper. Where the sun has been obscured for any period there is a gap in the streak. The total length of the streak (excluding these gaps) is a measure of the hours of bright sunshine. The paper should be set so that the spot of light at mid-day (local time) is directly over the 12 o'clock mark on the paper.

Care should be taken that the paper lies flat against the inside of the cylinder, and that it does not curl up or become displaced during the time the record is being made.

In adjusting the position of the instrument it is necessary to see—

(1) that the base is absolutely level;

(2) that the cylinder is tilted and set to the latitude of the particular locality;

(3) that the instrument lies in the meridian of the Station, *i.e.*, so that the readings are in local time and not Greenwich Mean time.

Further particulars of this instrument are to be found in Marriott's "Hints to Meteorological Observers" and "The Observers Hand-book" (Meteorological Office).

Wind Instruments.

Wind is clearly defined as air in motion near the earth's surface and in any direction parallel to this surface. Air moving towards or away from the earth comes under the definition "air current."

The two important measurements in connection with wind are its direction and its velocity. The former is measured by the wind vane indicating from which point of the compass the wind is travelling. The wind vane is so familiar to all that description is needless, but it is of importance that movement of the vane should be as free as possible so that it may respond to the slightest breeze. Direction readings should be taken twice a day and recorded monthly in the form of a "wind rose" (See diagram). Such a diagram explains itself, and from it one can see at a glance the direction of the prevailing wind during that particular month.

For measuring wind velocity and the amount of wind in a given time various types of instruments called anemometers are used. The simplest type measures the miles of wind per day and consists of four metal cups mounted at the ends of two diagonally fixed metal rods of equal length. This structure is

pivoted horizontally on ball bearings at the centre of balance, and is revolved in one direction by the slightest gust of wind from any quarter. This revolving motion is transmitted by cog wheels and a shaft to a pointer registering in miles on a dial face, the reading of which is taken every day at the same time.

For registering actual wind velocity the wind is led into a tube connected with a column of mercury the level of which varies according to the pressure of the wind, or in other words, its velocity.

Barometers.

These instruments, used for measuring the pressure of the atmosphere, may be of either the mercury tube type, or of the aneroid type. Of the former type, that known as Fortin's Barometer is the commonest. It is essentially a glass tube about 36 inches long, and about ⅜ inch diameter, which has been filled with mercury and then inverted over a small reservoir of mercury. Some of the mercury falls out of the tube, leaving a vacuum above the level of the mercury in the tube. The height of the mercury (from the level of the mercury in the reservoir to the level of that in the tube) is equivalent to the pressure of the atmosphere in that particular locality. If the atmosphere were absolutely dry, the height of the mercury would be exactly 760 millimetres, and this is the greatest length possible for the mercury column in a barometer. The atmosphere contains, however, more or less water vapour, which is lighter than air, and consequently, the more water vapour there is in the atmosphere, the less its pressure, and the shorter the column of mercury it can support. Thus when wet weather is imminent, the barometer "goes down" owing to the increase in water vapour in the atmosphere lowering its pressure.

In the Fortin's barometer the glass tube and reservoir are protected by a metal casing. An accurate scale is provided so that very small changes in level can be measured.

In the reservoir there is an adjusting screw for keeping the level of the mercury always the same. This level should cor-

respond exactly with the point of an ivory stud which is fixed to the top cover of the reservoir and points downwards.

The level of the mercury in the tube, which is to be read after adjusting the level in the reservoir, is convex, and readings must always be taken at the top-most point of this convexity.

The barometer should be placed in a well enclosed room, not exposed to sunlight, and subject to as little change in temperature as possible. There should however be good light, in order that readings taken may be accurate. The exposed parts should be kept clean, using if necessary a damp cloth. Care must be taken to prevent jolting or other movement of the instrument.

If it is suspected that the barometer is out of order through air entering above the mercury level, the instrument should be tilted slowly till the mercury touches the top of the tube. A slight click indicates the presence of a vacuum, while if no sound is audible, air has entered, and the instrument must then be sent away for repair.

Aneroid Barometer.

The variation in pressure of air is measured, in the aneroid barometer, by its effect on a thin hollow metal cylinder, or series of cylinders, exhausted of air and actuating a lever and pointer, indicating changes in pressure on a dial. These instruments are in very general use since they are less cumbersome than the mercury barometers. They are however liable to sudden changes and are not sufficiently reliable or accurate for meteorological work in India.

The barograph, or recording barometer, is of the aneroid type, and is a very useful and compact instrument. A series of flat metal cylinders connected together in vertical series is used, and the collapse or inflation of these cylinders with changes in pressure is transmitted in the usual way to a pointer tracing a line on a chart. The same remarks as in the case of other recording instruments apply regarding cleaning, care and adjustment of this instrument.

The observatory consists of an eight yards square grass plot, fenced in, containing the following :—

Lay out of the Meteorological Station at Tocklai.

1. A combined anemometer and wind vane mounted on a 20 feet tower in the centre of the plot.
2. A "Stevenson screen" containing maximum and minimum thermometers, recording thermometer and hygrometer, and the glass measuring cylinder for the rain gauge.

   The Stevenson Screen is a wooden box with "louvred" sides, and a double roof, made to the specifications of the Indian Meteorological Department. The box is mounted on four posts set in cement, and stands about four feet from the ground.
3. Solar radiation thermometer four feet from the ground.
4. Terrestrial radiation thermometer six inches from the ground.
5. Rain gauge.
6. Sunshine recorder on pedestal four feet high.
7. Sun clock (or helio-chronometer) giving accurate local time to one minute.
8. One foot and three feet soil thermometers.

In the Offices are :—

1. Mercury Barometer (Fortin's).
2. Recording Barograph.

On the Office verandah are :—

1. Wet and dry bulb Hygrometer
2. Hair Hygrometer.
3. Six's maximum and minimum thermometer.

TEA GREEN FLY.

(Empoasca flavescens-Fabr.)

BY

E. A. ANDREWS.

In Part IV of the Issue of this Journal for 1923, a note was published on certain breeding observations made in connection with green-fly.

These observations have been continued since, and additional points have been brought out which are of sufficient interest to be worthy of note.

The first observation to be made is that the generally accepted idea that green-fly causes stunting of the bush still remains unproven. Attempts have been made, each season, to produce the stunting effect on tea bushes kept in cages, by steadily introducing numbers of the insects onto them, but without any apparent result. This confirms the observations of Watt and Wright, in so far as one negative result can confirm another, and adds force to the possibility of the appearance of the stunted effect, at the time when green-fly reaches its most active condition, being only a coincidence.

Further weight is added to these results by the fact that, whereas the period June to July is usually regarded as the "green-fly season," and is, as a matter of fact, a period at which green-fly has reached its maximum activity, yet, although the "green-fly effect" goes off in August and September, the activity of the insects continues undiminished, and it is not until October that their rate of development shows any definite sign of showing slowing down. This is clearly shown by the breeding records.

The evidence so far obtained in this connection, therefore, would appear to sway the balance against the idea that green-fly produces stunting of the flush of the bush.

As a result of the further observations which have been made, it is now possible to modify the tables for the development of the insect in the different stages, given previously, as follows :—

First Larval Stage.—The number of days spent in this stage during the various months of the year is as follows :—

Month.	Longest period.	Shortest period.	Usual period.
January	6	1	3 or 4
February	5	1	2
March	3	1	2
April	3	1	1
May	3	1	1
June	3	1	1
July	3	1	1
August	3	1	1
September	3	1	1
October	3	1	1
November	3	1	1
December	6	1	2 or 3

Second Larval Stage.—The number of days spent in this stage during the various months of the year is as follows :—

Months.	Longest period.	Shortest period.	Usual period.
January	7	2	3 or 4
February	7	2	2
March	4	1	2
April	5	1	2
May	4	1	2
June	4	1	2
July	3	1	2
August	3	1	2
September	3	1	2
October	3	1	2
November	4	1	2 or 3
December	7	1	3

Third Larval Stage.—The number of days spent in this stage during the various months of the year is as follows :—

Month.	Longest period.	Shortest period.	Usual period.
January	9	2	4
February	5	2	3
March	5	1	3
April	4	1	2
May	4	1	2
June	4	1	2
July	4	1	2
August	3	1	2
September	4	1	2
October	6	1	2
November	6	1	2
December	8	1	3

Fourth Larval Stage.—The number of days spent in this stage during the various months of the year is as follows :—

Month.	Longest period.	Shortest period.	Usual period.
January	7	1	3 to 5
February	5	2	2
March	5	1	2 & 3
April	5	1	2
May	4	1	2
June	4	1	2
July	4	1	2
August	4	1	2
September	4	1	2
October	5	1	2
November	7	1	2 & 3
December	13	2	4

Fifth Larval Stage.—The number of days spent in this stage during the various months of the year is as follows :—

Month.	Longest period.	Shortest period.	Usual period.
January	7	2	6 or 7
February	10	3	3 to 5
March	7	1	4
April	7	2	3 or 4
May	4	1	3
June	4	1	2
July	4	1	2
August	4	1	2
September	4	1	2
October	6	1	3 & 4
November	7	2	4
December	10	2	7

From the above records it is possible to compile a table showing the longest and shortest periods the insects may take, at different times throughout the year, for development from the egg to the adult stage, and the limits between which development usually takes place. Such a table is given below :—

Month.	Longest period.	Shortest period.	Usual period.
January	36	8	19 to 24
February	32	10	13 to 15
March	24	5	13 or 14
April	24	6	10 or 11
May	19	5	10
June	19	5	9
July	18	5	9
August	17	5	9
September	18	5	9
October	23	5	10 or 11
November	27	6	11 to 13
December	44	7	19 or 20

The question arises as to whether this extreme variation in the length of the life history actually takes place, or whether, in cases in which one stage becomes prolonged, a later stage will be passed through in a shorter time and thus maintain the average life cycle. It is known that in certain insects this does occur, while in others the duration of the life cycle may be shortened or prolonged by adjustment of environment conditions.

Having now obtained records of several hundreds of completed life cycles it is possible to compare the actual figures obtained with those calculated above, and in the following table the actual figures are given for comparison.

Month.	Longest period.	Shortest period.	Usual period.
January	28	14	19
February	21	13	13 to 15
March	16	11	13
April	14	7	10
May	16	6	10
June ...	12	5	9 to 10
July	13	5	9 to 10
August	13	5	8 to 10
September	13	6	8 to 10
October	14	6	9 to 11
November	18	9	12 to 14
December	30	14	20

It will be observed that the longest period actually taken to attain maturity falls short of what would be the case if the insect developed at the slowest possible rate during each stage, while at the height of the season certain of the insects pass through each stage at the quickest possible rate, though in the earlier and later months this does not occur. At the same time, the range of variation which is actually found to occur is considerable, so that at the height of the season certain individuals take as long to develop as others passing through their life cycle in the cold weather months.

On the whole, however, the life cycle slows down as the cold weather approaches, and accelerates on the advent of the rainy season, and it might be supposed that in the case of climatic conditions specially unfavourable to the insect the length of the life cycle might tend to approach the longest limit, and *vice versa.*

Observations of climatic conditions, made concurrently with the breeding observations, hardly support this supposition.

There is a distinct seasonal variation, the rate of development increasing as the rain-fall and temperature increase, and

decreasing as they diminish, with the maximum rate of development occurring in June to September, the wettest and hottest months.

It is also found that the only irregularity in the development curve occurs in May, in which month, in this district, there is a check in the rain (between the "chhota bursat" and "burra bursat") and a distinct increase in the number of hours of bright sunshine; the irregularity consisting in a slight check in the increasing rate of development.

The following table, giving the average rate of development of all insects reared to maturity, and the mean value of the various climatic factors prevailing during the period of the observation, shows this :—

Month.	Days to attain maturity (average)	Rainfall (inches)	Average Humidity (%)	Average Maximum Temp : (°F)	Average Minimum Temp : (°F)	Hours of sunshine per day
January ...	22·6	0·87	87	72	50	6
February ...	16·4	0·49	78	77	53	7
March ...	13·3	4·26	78	80	61	6
April ...	10·8	9·27	80	82	67	4
May ...	10·7	9·13	83	85	71	5
June ...	9·5	10·74	84	89	75	4
July ...	9·0	16·96	84	90	77	4
August ...	8·9	14·04	85	89	76	4
September ...	9·2	10·46	86	88	74	5
October ...	10·4	3·80	84	85	71	6
November ...	13·0	1·12	83	79	59	6
December ...	19·7	0·46	88	74	52	5

When, however, the behaviour of the insect in one month of any year, as contrasted with its behaviour in the same month of another year, is compared with the corresponding climatic factors, it is found that year by year, in a given month, in spite of variations in climatic conditions, the usual rate of development of the insect remains approximately the same, as is evi-

denced, for example, by the following figures for June, the "green-fly month."

Year	Days to attain maturity (average)	Rainfall for the month (inches)	Average Humidity (%)	Average Maximum Temperature	Average Minimum Temperature	Hours of sunshine per day
1920	9·7	9·89	91	89	73	...
1921	9·8	7·71	84	88	78	4
1922	9·6	11·67	84	90	76	4
1923	9·8	20·29	89	88	76	5
1924	8·5	6·36	79	91	78	4
1925	9·6	9·50	80	90	73	5
1926	9·1	9·73	82	89	74	4

It will readily be seen that any significance which the small variations shown by the average figures might be supposed to possess disappears when the breeding records are examined more closely, for it is then found that insects which emerge from the egg on the same day (of the same month of the same year) show variations much in excess of any in the above table.

Some of the more extreme of these cases are quoted in the following table—

Date of emergence.	Date of attaining maturity.	No. of days.
June 5	June 10	5
"	" 14	9
"	" 18	13
"	" 17	12
August 25	September 2	8
"	" 1	7
"	" 8	14
September 27	October 7	10
"	" 8	11
"	" 10	13
"	" 3	6
"	" 6	9
"	" 6	9

Variations of three and four days in the time taken to attain maturity, in the case of insects emerging from the egg on the same day, were common. In all cases insects which emerged on the same day were reared to maturity under identical climatic conditions. It is therefore obvious that these variations are independent of variation in those conditions, and since

they are of far greater significance than any variation shown from year to year, it can only be concluded that such climatic variations as are experienced, from year to year, at Tocklai, are well within the limits beyond which an effect would be produced on the development of the insect.

Therefore, climatically speaking, all years are equally favourable for the development of green-fly, and variation in the stunting of the flush of the bush, attributed to green-fly, from year to year, may be due to some cause independent of green-fly.

This adds further weight to the belief, deduced from evidence given above, that green-fly may not be the cause of the stunting of the flush of the bush which has come to be known as the "green-fly effect."

It remains to account for the enormous variation in the rate of development shown by green-fly insects which emerge from the egg on the same day. This may be due to intrinsic physiological differences in the insects themselves, or, which is conceivably possible since each insect in captivity has to be given a separate shoot to feed on, to differences in the food supply.

In the latter event, it might be supposed that, since a fresh shoot is given to the insect each day, its food would on one occasion be more suitable, on another occasion less so, and that on the average things would level up, and retardation of development at one stage of its development be followed by acceleration at another. This would undoubtedly be so, and indeed undoubtedly is so, for in the majority of instances, although in many cases passing through the different stages in different periods, insects hatched on the same day took approximately the same time to attain maturity. Experiments will be carried on during the coming season to ascertain how far the food supply affects the question.

The continued observations have confirmed the remarks previously made with regard to the longevity of green-fly, especially in the cold weather months, during which period they have been kept alive for as long as three months.

SOME OBSERVATIONS ON VIOLET ROOT ROT.

(*Sphaerostilbe repens*, B. and Br.)

BY

A. C. TUNSTALL.

On most tea gardens some tea bushes may be found to be fading away for no apparent reason. Year by year they become weaker and weaker until finally they give up the struggle. In many cases these mysterious deaths occur in patches. If one of these bushes be dug up it will be found that the roots frequently have a mauve or violet tint. The removal of a portion of the discoloured bark will reveal white to orange coloured bands of fungus mycelium ramifying over the wood just below the bark. In the dead portions of the root these bands become purplish black and here and there on the dead bark little clusters of pin-shaped bodies are often found. These resemble the fructifications of Red rust but they are much larger and have hairs on their stalks. Moreover they are usually produced below ground. Occasionally a second form of fructification may be found, small dark red spherical bodies resembling the fruits of *Nectria*. On the dead portions of the root the mycelium of the fungus often projects in little branching clusters resembling rootlets but usually black in colour. If the soil in the neighbourhood of the infected bush be carefully examined the mycelium of the fungus may be found in rounded strands resembling young roots.

This fungus is very frequently present in soils in North-East India and many jungle tree roots are attacked by it. The roots of the Jak fruit tree are almost invariably attacked in the district round Tocklai. In spite of the presence of the fungus the infected trees do not appear to suffer any serious damage. The fungus is also occasionally found on the roots of vigorous and apparently healthy tea bushes. It would appear therefore that this

fungus does not necessarily cause serious damage so long as conditions are otherwise favourable to the infected plants.

It was at one time considered that the presence of this fungus was associated with excessive acidity of the soil, but later investigations showed that it could also thrive in neutral or even alkaline soils. Changing the acidity of the soil did not therefore have any direct effect on the growth of the fungus. It was noticed, however, that the fungus was most prevalent on badly aerated soils. Soils of such a nature are also bad for the tea bush and in most cases the bushes growing on them are being attacked and damaged by this fungus. The bushes on adjoining, better aerated soil, are also frequently attacked but show no apparent signs of damage.

In these circumstances it is obvious that the recognized treatment for root disease, *i.e.*, the removal of diseased bushes and their immediate neighbours, is not likely to do much good.

Sterlization of the soil, by the addition of chemical substances, is also impracticable as the fungus is to be found well below the level to which sterilization is likely to be effective. The only reasonable method of treating this disease is by making the tea bush more vigorous and thus better able to withstand the attacks of the fungus.

The improvement of the condition of the tea bush is largely dependent on the improvement of the condition of the soil.

As this fungus is most prevalent on badly aerated soils, improvement in this respect should be the first consideration. Defective drainage should be remedied. The tilth should be improved by taking care to carry out the cultivation when the soil contains the right amount of moisture, and by the addition of organic matter.

The chemical defects of the soil should also be remedied by appropriate manuring with quick acting manures.

Another point of importance is that very poor bushes are unable, by reason of their restricted leaf area, to take immediate advantage of improved conditions. It is only through the agency

of the leaves that the plant is able to utilise the substances obtainable from the soil. It is desirable therefore under these circumstances to apply manures in small doses at frequent intervals. In order to give the plant the opportunity of making the most of the improved soil conditions it is desirable to leave it entirely unplucked for at least one year. Dead and moribund wood may with advantage be removed at the commencement of the treatment.

In spite of the careful nursing some of the bushes will in all probability fail to respond. Such bushes should be removed at the end of the first year as experience has shown that it is more satisfactory to replace them.

To summarise :—

1. Remove all dead and very poor bushes.

2. Improve the mechanical condition of the soil by—
    1. better drainage
    2. the addition of organic matter
    3. care in the selection of the times at which cultivation should be carried out.

3. Improve the chemical condition of the soil by the addition of appropriate manures.

4. Allow the poorer bushes to remain unplucked to enable them to take immediate advantage of the improved conditions.